IPM CRSP Annual Highlights

For Year 10
(2002 - 2003)

Office of International Research, Education, and Development
University Outreach and International Affairs
Office of the University Provost
1060 Litton Reaves Hall
Blacksburg, Virginia 24061-0334

Virginia Tech
VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

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Contact Address for the Management Entity

IPM CRSP
Office of International Research, Education and Development
1060 Litton Reaves Hall
Virginia Tech
Blacksburg, VA 24061-0334

Telephone (540) 231-3513
FAX (540) 231-3519

E-mail: ipm-dir@vt.edu

IPM CRSP US Institutions

Florida A&M University
Montana State University
Ohio State University
University of Georgia
Penn State University
Purdue University
Virginia Tech
USDA Veg. Lab.
University of California -Davis
University of California - Riverside
North Carolina A&T University
Fort Valley State University

Host Country Institutions

Guatemala - Agri-lab, ALTERTEC, ICTA, ICADA, UVG
Jamaica - CARDI, Ministry of Agriculture
Mali - IER
Philippines - NCPC/UPLB, PhilRice
Uganda - Makerere University, NARO
Ecuador - INIAP
Eritrea - DARHRD
Albania - PPI, FTRI, AUT
Bangladesh - BARC, BARI
Honduras – EAP, FHIA

International Centers

AVRDC - Taiwan
CIAT - Colombia
CIP - Peru
ICIPE - Kenya
IRRI - Philippines
IFPRI - USA

Private Sector

NOGROCOMA, Philippines

NGOs/PVOs

CLADES; GEXPRONT,Guatemala; CARE,Bangladesh

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INTRODUCTION

The IPM Collaborative Research Support Program (IPM CRSP) is a United States Agency for International Development (USAID) funded program which consists of a consortium of IPM disciplines from U.S. universities and host county institutions working collaboratively to reduce 1) agricultural losses due to pests; 2) damage to national ecosystems; and 3) pollution and contamination of food and water supplies. The goals of the CRSP are to develop improved IPM technologies and institutional changes that will increase farmer income, reduce pesticide use and pesticide residues on domestic and export products, improve IPM research and education program capabilities, improve ability to monitor pests, and increase the involvement of women in IPM decision making and program design. A Board of Directors, an External Evaluation Panel and a Technical Committee guide the IPM CRSP programs. For more information on the IPM CRSP see the website: http://www.ag.vt.edu/ ipmcrsp/index.asp

Working towards the above-mentioned goals, the IPM CRSP has the following specific objectives:

- Identify and describe the technical factors affecting pest management.
- Identify and describe the social, economic, political, and institutional factors affecting pest management.
- Work with participating groups to design, test, and evaluate appropriate participatory IPM strategies.
- Work with participating groups to promote training and information exchange on Participatory IPM.
- Work with participating groups to foster policy and institutional changes**.**

The research activities of the IPM CRSP are based on close collaboration between scientists of the participating host countries and U.S. institutions. The participating host country sites of the CRSP during Year 10 included Albania, Bangladesh, Ecuador, Guatemala, Honduras, India, Jamaica, Mali, the Philippines, and Uganda. Among the active partner US institutions are: University of Georgia, Montana State University, Ohio State University, Pennsylvania State University, Purdue University, University of California-Davis and Riverside, North Carolina A&T University, Florida A&M University, Fort Valley State University, USDA Vegetable Laboratory, and Virginia Tech (VT) with VT as the lead and the Management Entity (ME) institution.

This report highlights the activities of the IPM CRSP during Year 10 of its operation. The major portion of the report is devoted to brief summaries of IPM CRSP activities on a regional basis: Africa, Latin America, Asia, Caribbean, and Eastern Europe. This document covers, for each site in a region, a description of the collaborative program, IPM constraints addressed, training and other institution building activities, networking and selected research accomplishments. This report highlights the increasing intensity of technology transfer to farmers with the maturity of many of the research programs. The remaining sections of the report cover several major activities of the CRSP such as the Board of Directors Meeting, Technical Committee Meetings, and Trip Reports. Details on each of these topics and other related items are given in the site reports of the Year 10 Annual Report of the IPM CRSP.

The Site Chairs, host country Site Coordinators, collaborating scientists, and the Management Entity contributed to this report. The Site Chairs and host country Site Coordinators during Year 10 were:

West Africa Site in Mali: Keith Moore, Virginia Tech (Site Chair); Kadiatou Touré Gamby, IER (Site Research Coordinator); Bouréma Dembélé, IER (Site Administrative Coordinator).

East Africa Site in Uganda: Mark Erbaugh, Ohio State University (Site Chair); Sam Kyamanywa, Makerere University (Site

Coordinator); George Bigirwa, NARO (Deputy Site Coordinator).

South America Site in Ecuador: Jeff Alwang, Virginia Tech (Site Chair); Carmen Suárez, INIAP (Site Coordinator); Victor Barrera, INIAP (Vice Site Coordinator).

Central America Sites in Guatemala and Honduras: Steve, Weller, Purdue University (Site Chair); Luis Calderon, ICADA, Guatemala (Site Coordinator).

Caribbean Site in Jamaica: Sue Tolin, Virginia Tech (Site Chair); Dionne Clarke-Harris, CARDI (Site Coordinator).

Southeast Asia Site in the Philippines: Sally Miller, Ohio State University (Site Chair); Aurora M. Baltazar, PhilRice (Site Coordinator); Herminia Rapusas, PhilRice, (Interim Site Coordinator)

South Asia Site in Bangladesh: Ed Rajotte, Pennsylvania State University (Site Chair); Rezaul Karim, Horticulture Research Center, BARI (Site Coordinator)

Eastern Europe Site in Albania: Doug Pfeiffer, Virginia Tech (Site Chair); Josef Tedeschini, Crop Protection Institute, Durres (Site Coordinator)

The following Management Entity personnel contributed to this report:

S. K. De Datta, Associate Provost for International Affairs, Director of the Office of International Research, Education, and Development (OIRED), and Principal Investigator of the IPM CRSP.

E. A. “Short” Heinrichs, Interim Program Director, IPM CRSP, Virginia Tech.

Greg Luther, Assistant Program Director, IPM CRSP, Virginia Tech.

Debbie Glossbrenner, Financial Services Associate, IPM CRSP, Virginia Tech.

Overview of the East Africa Site in Uganda

J. Mark Erbaugh, Site Chair (The Ohio State University); Samuel Kyamanywa, Site Coordinator (Makerere University); George Bigirwa, Deputy Site Coordinator (NARO/NAARI)

The Collaborative Program

The IPM CRSP Uganda Site is a collaboration of Makerere University Faculty of Agriculture (MU/FA), the Ugandan National Agricultural Research Organization (NARO), the Ministry of Agriculture, Animal Industries and Fisheries (MAAIF) Extension Service, participating farmer NGO groups, and scientists from IPM CRSP USA institutions. The program in Uganda operates under a Memorandum of Understanding with Makerere University Faculty of Agriculture. Dr. Samuel Kyamanywa, Chair of the Department of Crops Sciences at MU/FA is the Uganda Site Coordinator. He is directly linked to the National Agricultural Research Organization (NARO) through the Deputy Site Coordinator who is appointed by the Acting Director General of NARO, Dr. Otim-Nape. Dr. G. Bigirwa is the Deputy Site Coordinator, and also the leader of NARO's Maize Research Team. The IPM CRSP collaborates with research scientists from four NARO research institutes: Kwanda Agriculture Research Institute (KARl), Namulonge Agricultural and Animal Research Institute (NAARI), Serere Agricultural and Animal Research Institute (SAARI), and the Coffee Research Institute (CORI).

The IPM CRSP team in Uganda consists of six co-PIs and five graduate students from MU/FA, nine co-PIs from NARO, and three extension agents, representing six separate disciplines. Collaborating with Uganda co-PIs are eight USA-based co-PIs representing four disciplines from three universities: Ohio State University, Virginia Tech, and Fort Valley State University. Dr. Anton Baudoin, Plant Pathology, Virginia Tech, is a new collaborating scientist. This multi- institutional and disciplinary program is coordinated by the Site Chair, Dr. Mark Erbaugh, Ohio State University.

Throughout the year, site management is facilitated by weekly contact between the Site Chair and Coordinator, and all co-PIs are encouraged to maintain regular communication on individual research activities with respective collaborating scientists. However, the normal sequence of activities used to plan and implement Uganda site activities in past years was slightly altered this year due to the Site Coordinator's illness and a request that Year 11 work plan activities be closely aligned with USAID/Kampala Strategic Objectives. To expedite this request, the Site Chair traveled to Uganda in early January to hold discussions with USAID/Kampala. These discussions suggested that activities that support the transfer of improved agricultural technologies to farmers coupled with those that promote and improve Uganda's capacity to expand production quantity and quality of key commodities and advance Uganda's capacity to use biotechnology would be in support of USAID/Kampala's Strategic Objective 7: Expansion of Sustainable Economic Opportunities for Rural Sector Growth. The rationale behind this objective is that increasing agricultural productivity in Uganda is the primary strategy for reducing poverty and that this must be realized from a sustainable use of natural resources. The integrated pest management activities that emerged from the site collaborative planning process over the ensuing months reflect and support SO-7.

A three day work plan development meeting was held in Kampala in early March at which 22 Uganda site co-PIs and graduate students provided brief research progress reports and discussed new work plan activities in lieu of discussions with USAID/Kampala. Preliminary work plans were drafted following this meeting. The Site Coordinator and the Director of CORI then traveled to the United States to attend the IPM CRSP annual Technical Committee meeting held in Indianapolis,

Indiana, April 10-13. In site breakout sessions at this meeting, draft work plan activities were substantially altered and taken back to Uganda for full discussions with Ugandan co-PIs, USAID/Kampala, NARO, and the Chief of Party of the USAID-funded Investing in Developing Export Agriculture Project (IDEA). These discussions and communications between Uganda and USA co-PIs resulted in a new draft work plan that was submitted to the IPM CRSP ME in mid-June. However, these plans were again revised in meetings held in Uganda with the Site Chair and Dr. Baudoin with a final draft work plan being submitted to the ME in late July. Two last events in this year's cycle were the annual report preparation meeting held in Jinja, October 3-4 and the All African Crop Science Society Meetings held in Nairobi, October 13-17.

The Site Coordinator administers the implementation of field research activities with local co-PIs and extension agents during Uganda's two rainy seasons: the longer season roughly extends from April through early July, and the short rains extend from September through December. Linkages with local extension agents have facilitated the implementation of a farmer participatory approach to integrated pest management (PIPM) technology generation and transfer. They provide scientists and graduate students with the necessary linkages with local communities and farmer groups. The number of farmer groups has been expanded to include five each in Kumi and Pallisa districts and four in Iganga and Mayuge districts. The site continues to cooperate with an informal grouping of tomato growers in Mpigi District. In turn, extension agents work with NARO and Makerere scientists in the conduct of on-farm research, farmer field training schools, and also help coordinate graduate student field research activities.

Planning and support for IPM CRSP activities in Uganda involved communication and collaboration with USAID/Kampala, the IDEA Project, the Rockefeller Foundation through the Forum on Agricultural Resource Husbandry, germplasm exchanges with AVRDC, IITA, ICRISAT/Malawi, and CIMMYT/Harare, and several collaborative interactions with ICIPE. The IPM CRSP, ICIPE, NAARI's Biological Control Unit and Maize Research Team, and Makerere University scientists combined to provide financial and technical support for a MU graduate student, Ms. Teddy Kauma, to rear, release and monitor the introduced parasitoid *Cotesia flavipes.* This collaboration continued this year and will continue in the upcoming year with a focus on identifying, releasing, and monitoring parasitoids of the groundnut leaf miner (*Aproaerema modicella*). Co-PI Dr. R. Pratt, continues to coordinate research efforts to determine molecular marker-assisted selection procedures for improvement of multiple maize disease resistance with scientists from CIMMYT/Harare, the Grain Crops Research Institute in South Africa, and NARO's Maize Research Team. This collaborative effort was the recipient of a special bio-technology research award from the IPM CRSP ME. Additionally, Dr. Pratt was the recipient of a National Science Foundation travel award to attend the African Crop Science Conference and to expand collaborative links in biotechnology with other regional scientists. USAID/Kampala continues to provide funding support with a match from the IPM CRSP ME to investigate the etiology, epidemiology and integrated management of coffee wilt *(Fusarium xylarioides).* The editorial staff of the African Crop Science Journal provided in-kind support for the production of the proceedings from the IPM Conference for Sub-Saharan Africa. Finally, the Rockefeller Forum provided opportunities to cost share outreach activities and three graduate student activities through Makerere University.

IPM Constraints Addressed

The primary IPM constraints addressed at the Uganda site are: 1) poor linkages between research scientists and farmers; 2) lack of alternatives to multiple applications of chemical pesticides, particularly for important legume crops such as groundnuts and cowpeas in eastern Uganda, but also for tomatoes; 3) research fragmentation caused by insufficiently integrated research activities of multiple institutions and disciplines; and 4) limited distribution and dissemination of IPM technologies. In order to address these constraints the Uganda site implemented a participatory approach to the conduct of IPM research. The initial field PA held with farmers at research sites in Iganga and Kumi

Districts in 1995, and now verified by two baseline surveys, identified priority crops and pests. This helped orient research to solving farmer problems - demand driven activities. Subsequent activities including farmer field pest monitoring, farmer open days, and on-farm trials added to or amended pest and disease priorities. Priority insect pests and diseases by crop being addressed in the IPM CRSP research program are as follows: **cowpea:** cowpea aphid *(A. craccivora),* cowpea flower thrips *(Megalurothrips sjostedti), Maruca* sp. pod borers, *M. vitrata,* pod sucking bugs, and the bruchid beetle *(Callosobruchis chinesis);* **groundnuts:** groundnut rosette virus disease, aphids *(Aphis craccivora* Koch the vector of rosette disease), Cercospora leaf-spot *(Cercospora arachidicola),* the groundnut leaf miner *(Aproaerema modicella),* foot rot *(Sclerotium rolfsii)* and thrips *(Megalurothrips sjostedti, Thrips palmi* Kamy, *Frankliniella schultzie* Trybom, *Scirtothrips dorsalis* Hood, and *Caliothrips indicus);* **maize:** stalk borer (*Chilo partellus* Swinhoe), Gray leaf spot (*Cercospora zeae-maydis)* and termites *(Macrotermes, Pseudacanthotermes* and *Microtermes);* **sorghum**: stalk borer (*Chilo partellus* Swinhoe), and the parasitic weed, *Striga;* **tomato:** late blight *(Phytophthora infestans),* bacterial wilt *(Ralstonia solanacearum)* and thrips *(Thrips tabaci* and *Frankliniella sp.);* **maize and groundnut** moulds and mycotoxins *Aspergillus, Fusarium, Rhizopus* and *Penicillium* species; and, **coffee:** coffee wilt *(Fusarium xylarioides* (telemorph=*Gibberella xylarioides*). Researcher interactions with farmers also suggested component technologies that have been integrated into trials. Local farmers suggested the interplanting of *Celosia argentia* with sorghum, and the use of cotton in rotation, to reduce the incidence of *Striga;* and, the use of several locally available bio-rational products in post-harvest storage to reduce bruchid damage.

The Year 10 work plan was organized into six topical areas that address these constraints: (1) Developing and disseminating IPM packages for important legume (cowpeas and groundnuts) and cereal crops (maize and sorghum) with transition farming systems in eastern Uganda; (2) Developing IPM packages for tomato production in central Uganda. The development of pest management alternatives for both legume and horticultural crops is particularly important because the production of these crops is associated with excessive use of pesticides; (3) Identifying on-farm practices/factors which influence mould incidence and mycotoxin contamination of maize in order to develop appropriate post-harvest disease management options; (4) Conducting socioeconomic assessments of crops and technological packages including a tomato marketing assessment and an adoption study of IPM packages for cowpea and groundnuts; (5) Developing and disseminating IPM informational outputs for the IPM CRSP Uganda site; and, (6) Examining the etiology, epidemiology and integrated management of coffee wilt *(Fusarium xylarioides* (telemorph=*Gibberella xylarioides*). This is an affiliated activity with funding from USAID/Kampala and the IPM CRSP Management Entity (ME). Additionally, the Uganda site planned and hosted a GIS training session and produced the proceedings of the IPM Conference for Sub-Saharan Africa.

Institution Building

One of the main contributions to institutional capacity building by the IPM CRSP Uganda Site has been in human resource development. This contribution was recognized in the report of the external IPM review panel to SPARE, which noted that the "Strong USAID (IPM CRSP) association with Makerere University in Uganda deserves special mention. Graduate student training at Makerere University has helped facilitate domestic and international institutional collaborations and has contributed to research output." Twenty Ugandan graduate students have completed their MS degrees or have submitted their theses. The CIAT, CIP and IITA programs in Uganda have each hired one of these graduates; two have accepted jobs with the newly created National Agricultural Advisory Service; three are pursuing doctoral degrees at international institutions; and two are pursuing doctoral degrees at Makerere. Ms. Jackie Bonabana completed her M.S. degree in Agricultural Economics at Virginia Tech and is now pursuing a PhD at the same university with funding from the Peanut CRSP; Mr. Godfrey Asea is pursuing a PhD in plant breeding at OSU; and, Mr. A. Kaaya completed his course work in food safety at Virginia Tech and is now in the process of

completing his dissertation work at Makerere University.

There were 12 trips made to the Uganda site this year by USA based co-PIs and IPM CRSP administrators. Attending the IPM Conference for Sub-Saharan Africa were the following: IPM CRSP Principal Investigator, Dr. S.K. DeDatta; USAID/IPM CRSP CTO, Dr. Robert Hedlund; Site Chair, Dr. M. Erbaugh; and Co-PIs, Drs. R. Pratt, R. Hammond and M. Ivey. Dr. G. Luther made two trips to Uganda to continue his collaborative effort with Dr. Kyamanywa and a Makerere University graduate student on the identification and biology of beneficial insects on cowpea and groundnuts. In late December, J. Bonabana returned to Uganda, after completing her M.S. degree at Virginia Tech, to begin lecturing and research from her position at Makerere University. In early January and late May, the Site Chair, Dr. Erbaugh, went to Uganda to develop Year 11 work plans, hold discussions with USAID/Kampala, and advise M.Sc. candidate Magdaline Amujal in her thesis preparation. Dr. Baudoin went to Uganda in late May to initiate discussions and advise on research related to field crop diseases and coffee wilt. Dr. G. Mbata was in Uganda at the same time to collaborate with Drs. Kyamanywa and Agona on field management of cowpea bruchids including the use of pheromone baited traps. Mr. Kaaya returned to Uganda in May after successfully completing his course work at Virginia Tech toward obtaining a Ph.D. In July, Dr. A Roberts conducted a five-day workshop on advanced ArcView GIS applications with eight students from Makerere University. OSU graduate student A. Alumai went to Uganda in July to identify indigenous entomopathogenic nematodes and implement field trials. Finally, Drs. Pratt, Erbaugh and Felix attended the All African Crop Science Society meetings in Nairobi in October. Also attending was OSU graduate student Godfrey Asea, who returned to Uganda to set up field trials following the conference. Dr. Erbaugh was in Uganda prior to the meetings to meet with USAID.

Networking:

Networking is facilitated by the functional links between the Site and Deputy Site Coordinators and their respective organizations, and close communication with the Site Chair. These linkages are reinforced by visits made by USA based co-PIs to the Director General of NARO, to the Dean, Faculty of Agriculture, and to Directors of participating research institutes. Preliminary research results are presented by co-PIs at annual meetings held in Uganda. Visits by the Site Chair always include update meetings with USAID/Kampala and other USAID sponsored efforts. Regional networking is conducted via electronic communication, research collaboration, and participation in professional societies and symposia. Formal research collaboration with ICIPE and the Rockefeller Foundation focuses on mutual contributions to graduate student training and advising. Direct communication between Uganda co-PIs and USA co-PIs have resulted in germplasm exchanges with AVRDC, IITA, CIP, ICRISAT, the USDA potato research program, and CIMMYT /Harare. Functional links with extension agents and farmer NGO groups are maintained to promote IPM development and technology transfer.

This year, regional networking was promoted through the participation of co-PIs and graduate students in regional fora including the All African Crop Science Society, the International Association for Farming Systems Research, the Rockefeller Forum, collaborations with ICIPE, and the Gray Leaf Spot Collaborative Network. Last year's special networking activity was the IPM Conference for Sub-Saharan Africa attended by over 190 people from nearly 20 different Sub-Saharan countries, 6 European and North American countries, and 4 CG Centers including CIP, IITA, CIAT, and ICIPE. In addition to the IPM CRSP, the Rockefeller Forum, ICIPE, UN/FAO, Dutch Government, USAID IDEA Project, NARO and Makerere University helped support the conference. A total of 140 papers were presented and 50 posters were displayed. Thirty-two papers were presented by IPM CRSP Uganda site co-PIs and graduate students. Dr. Kadiatou Toure Gamby represented the IPM CRSP West Africa Site in Mali at the conference. Printed and bound copies of the conference proceedings have been produced.

Research Highlights

Cowpea: Trials were conducted in Eastern Uganda to monitor the abundance of major arthropod natural enemies (NEs) in various combinations of cowpea monocultures and polycultures, and to look at effects of insecticides on these NEs. Parasitism of aphids by an aphidiid wasp and pod borers by tachinid flies, and the abundance of 7 predator groups (Coccinellidae, Staphylinidae, Syrphidae, Anthocoridae, Mantidae, Dermaptera and spiders) were considerably reduced by insecticides. Insecticides clearly and dramatically reduced NE numbers, and therefore seriously reduced the level of biological control occurring in the field. These insecticides (Cypermethrin and Dimethoate) are therefore not recommended for a cowpea IPM program in East Africa.

Effects from cropping systems were not as clear, but NE numbers showed a slight trend towards being higher in the two polycultures than in the cowpea monoculture. Statistical analyses showed that both polycultures (cowpea/sorghum and cowpea/greengram) did not support higher or lower NE numbers as compared to the cowpea monoculture, in most trials. However, for all the predator and parasitoid species except two, abundances were numerically higher in both polyculture treatments than in the monoculture. This may indicate a trend that could be demonstrated more conclusively with a different experimental design.

Whereas activity and incidence of parasitoids of cowpea aphids (*Aphis craccivora*) and pod borers (*Maruca vitrata*) were low, lady beetles, syrphid larvae, earwigs and spiders were able to significantly suppress population densities of aphids. The effect of their presence on cowpea yields needs to be investigated next. If these effects are significant, it would be useful to investigate the feasibility of developing mass rearing techniques for these predators for inundative release programs. Enhancement of existing populations through habitat management or other means may also be profitable.

Multi-locational (Kabanyolo, Pallisa, Kumi and Kaberemaido) trials were used to evaluate six improved varieties: MU-93, TVX 337-025$^{(B)}$, IT90-109 $^{(B)}$, KVU-12349, IT82D-516-2, and IT85F-2841 against two local cowpea varieties: Ebelat and Icirikukwai. Results showed that the selected genotypes performed differently at different environments demonstrating the effect of genetic by environment (G X E) interaction. Five out of six improved genotypes out-yielded the local checks with an average of 1000kg/ha, which is well above the national average of 300-500 kg/ha. The G X E analysis through the biplot revealed MU-93 as the best variety providing the most stable and highest yields in all environments. From the correlation coefficients pods per plant, pod length and seeds per pod had high and positive correlations with yield, implying that these were the traits that can be used for selection of high yielding genotypes.

The effect of splitting cowpea prior to storage on the oviposition rate, generation time, number and weight of emergent *Callosobruchus maculatus* adults was investigated. *C. maculatus* can develop on split cowpea seeds but the number of eggs and emergent adults is significantly reduced. The weights of emergent adult *C. maculatus* are significantly affected by splitting of cowpea seeds. This possibly affects the population of subsequent generations since the fecundity of females depends on body weight. Dehulled and split cowpea seeds are less attacked by *C. maculatus* and thus store longer, and dehulling improves cooking time, palatability, digestibility and nutritive value of cowpea.

Groundnuts: Studies to determine the effect of groundnut cropping systems and insecticide applications on the abundance and diversity of predators and parasitoids were conducted during the first rains (May-August) of 2003, in Bukedea, Kumi District. Results showed that aphid/leafminer parasitoid activities and parasitism were significantly affected by the rate of insecticide spray and that insecticide sprays (Cypermethrin+Dimethoate) reduced population densities of natural enemies by 30-80%. The abundance and diversity of predators was significantly affected by the cropping system, the time of sampling and the level of insecticide spray, and groundnut polycultures supported two times higher diversity and abundance of natural enemies than monocultures. Groundnut genotypes had no significant effect on population densities of predatory fauna. Overall, the voracity of spiders varied from one prey species to another. A spider

consumed 8.9 aphids, 2.1 thrips and 4.2 leafminers daily. The predation efficiency and acceptability of prey (aphids, leafminers and thrips) by spiders were low, compared to those of earwigs on aphids.

Previous studies indicated that farmers are generally unaware of and uninformed about thrips. However, on-going investigations by the IPM CRSP revealed that flower thrips (*Megalurothrips sjostedti*) were commonly found in association with groundnuts. Two approaches were used to determine the relationship between thrips population densities and groundnut yield: 1) varying natural thrips infestations by use of different pesticide spray regimes; and 2) artificially infesting caged groundnut plants with varying densities of thrips. There was a significant negative relationship between thrips population density and groundnut yield per hectare. Varying the spray regime significantly affected thrips population density, with the population density decreasing as the frequency of pesticide application increased. Based on a yield loss function, the economic injury level of thrips on groundnuts was calculated as 12 thrips per 10 plants under field conditions.

Maize: Gray leaf spot (*Cercospora zeae-maydis*) is considered the most important maize foliar disease in Uganda and probably throughout all of sub-Saharan Africa. The IPM CRSP maize team, with international collaborators including CIMMYT/Zimbabwe, launched a two-fold strategy, one of which was to initiate longer-term host resistance strategies using molecular tools to expedite development of resistant varieties. To date, new resistance genes (QTLs) for improvement of gray leaf spot in sub-Saharan maize germplasm have been identified on chromosomes 2 and 4 of resistant maize inbred VO613Y. Resistant progeny lines (VP31 and VP90) have been selected for resistance to *C. zeae-maydis* infection and for good agronomic traits. These lines have been crossed to a maize inbred line adapted to sub-Saharan African conditions (CML202) and an inbred adapted to the U.S. corn belt (B104). A program to use molecular maker assisted selection in a population of over 400 VP31 x CML202 $F_{2:3}$ progeny lines has been initiated during 2003 in Ohio.

Establishment of *Cotesia flavipes* Cameron, a braconid parasitoid of *Chilo partellus* Swinhoe (Lepidoptera: Crambidae) was monitored in the cropping season of 2002 and 2003 in Masindi and Kumi districts. *C. flavipes* had previously been released in 1997 through collaboration among the IPM CRSP, NARO/NAARI, and ICIPE. The rate of parasitism of *Cotesia sesamia* Cameron and of *C. flavipes* varied according to stemborer species and location. A high rate of host specificity was observed in the two districts with each parasitoid species exhibiting preference for the co-evolved host, suggesting probable absence of inter-specific competition. Specifically, the preference of *C. flavipes* to *C. partellus* and of *C. sesamiae* to *B. fusca* and *S. calamistis* indicates that both parasitoids are complementary in regulating the stemborer complex, a factor, which is (will be) crucial in the sustainability of the biological control programme.

Recoveries of *C. flavipes* in Kumi, but not Masindi, and its relatively consistent high parasitism rates (20-30%) over four seasons provide clear evidence that the parasitoid has been successfully established in Kumi, and is indicative of the potential of the parasitoid to significantly reduce stemborer populations over time. There is need for diversification of biological control strategies in Masindi to supplement the activities of the indigenous parasitoids. Such strategies could include redistribution of African parasitoids and introduction of more effective parasitoids.

Field experiments were conducted for two seasons to assess the efficacy of maize-legume intercrops and fish-bait application for the control of termites in maize. Termites can attack maize plants at any stage of development from seedling to maturity, with the most important being Microtermitinae. Field observations indicate that the much smaller *Microtermes* species begin their attack at the seedling stage, 4-5 weeks after plant emergence (WAE), and this increases to plant maturity, while damage by the larger *Macrotermes* species starts at tasselling stage and continues thereafter. Although application of baits at four WAE targeted *Microtermes*, the treatment was also successful in preventing damage from both *Microtermes* and *Macrotermes* populations, especially during the 2002b trial. Application of the baits at four and nine WAE was found to significantly increase activity of termite predating ants and reduced both

termite and stemborer damage to maize. However, results from the impact of the strategy on maize yield were not consistent. The results suggest that integrating maize-legume intercropping, particularly maize-*Desmodium* intercrop, with application of fish baits may be a useful strategy for management of termites in smallholder maize farmer situations.

Sorghum: *Striga* remains a major constraint to sorghum production in Uganda. During this field season, inter-cropping sorghum with silver leaf desmodium at a ratio of 1:1 reduced *Striga* emergence by 38% and improved sorghum yield by 39% over the control. This was 47% as good as nitrogen fertilizer in increasing sorghum yield. Treating both Epuripur and Sekedo seeds with 0.05% of 2,4-DB herbicide before planting reduced the number of *Striga* plants emerging by 83% compared to the control (susceptible local sorghum variety without seed treatment). Preliminary results of the third experiment indicate an average reduction in *Striga* emergence and improvement of sorghum yield by 45% over the other treatments when herbicide seed treatment, intercropping and fertilizer application are combined.

Tomatoes: Major tomato pests in Uganda include early and late blights (*Alternaria solani* and *Phytophthora infestans*), bacterial wilt (*Ralstonia solanacearum*), aphids, thrips, mites, and African bollworms (*Helicoverpa armigera).*

Bacterial wilt, which is soil-borne, has no chemical control available in Uganda. The IPM CRSP tomato program carried out on-farm trials to test 3 selected tomato introductions from the Asian Vegetable Research and Development Center (AVRDC) versus 2 older varieties for resistance to bacterial wilt. All clones, MT56, CLN2037B, Redlander, CLN2116B and CLN2123 showed resistance to bacterial wilt (98.6 - 100%), and were only severely infected by late blight in a few cases. The farmers have shown preference for MT56, Redlander, and CLN2037B, all which produce larger fruits than the other two varieties. Other farmers have taken the seed of MT56, Redlander, and CLN2037B and the fruits are being sold in markets at Matugga and Kaleirwe.

On-farm trials continued to determine the effect of selected management practices on the incidence of late blight (*Phytophthora infestans)* on tomatoes. The mulched, staked, and trellised plots had lower infection of late blight compared to the clean weeded plots, while highest total yields were obtained from mulched plots. Mulching, staking and trellising increased yields by 100%, 87% and 83% respectively.

Indigenous insect parasitic nematodes were recovered in Uganda and preliminarily identified as *Steinernema* sp. and *Heterorhabditis* sp. Further identification is to be done using molecular techniques. Trials were implemented but data is not yet available regarding the use of insect parasitic nematodes (*Steinernema carpocapsae*) as a possible control alternative to insecticides for management of thrips on tomato.

Previous studies determined that two indigenous solanaceaous root stocks were compatible as tomato scions and most resistant/tolerant to bacterial wilt. The root stocks selected to be used on farmers' fields for tomato grafting were *S. indicum* subsp. *dischum* locally known as Katunkuma, and *S. camplyacanthum* locally known as Kitengotengo. The scion used was the popular variety, Money Maker, and the top wedge method of grafting was used. The work was done with the Nakyesanja Farmers Association. After the demonstration, each participant was given a chance for hands-on practice, using simple tools which are readily available (like razor blades) instead of grafting knives and grafting tapes. Most of the grafts were successful. Within a week after grafting there were signs of growth and the polyethylene covers were removed. Monitoring and evaluation of pest and disease incidence on grafted tomatoes and assessment of the impact and economic implications is still on-going. During the anniversary of the coronation of the Kabaka of Buganda, the Association decided to include grafted tomato among their exhibits, and have included them in this year's exhibition for World Food Day celebrations.

Market studies revealed that fresh market retailers of tomatoes prefer visible signs of Dithane M-45 (DM45) on tomato fruits because they believe such fruits have a longer shelf life. The main objectives

of this study were to determine the effect of different levels of DM45 on the postharvest storage quality of tomato fruits and to establish the DM45 residue levels on tomato fruits obtained from markets. Tomato fruits from farmers in Busukuma Sub-county were subjected to three treatments of DM45 and analyzed, for microbial growth, % spoilage, firmness, acidity, pH and total soluble solids at a 4-day intervals, and DM45 residues. Tomato fruits were also purchased from three markets in Kampala and their DM45 levels determined. Results indicate that generally, in all quality parameters analyzed there was no significant difference (p 0.05) between fruit treated with recommended and excess DM45 levels. However, significant differences were observed between the control and treated fruit with the latter showing better fruit quality parameters throughout the storage period. The majority of untreated fruit (62%) was spoiled and could not be sold by day 16 of storage. *Rhizopus* rot, Sour rot, Gray mold rot and *Mucor* rot were the major spoilage diseases identified. DM45 residue levels increased with increasing treatment levels. However, both the control and treated fruit had more than twice the recommended DM45 residue levels. Fruit from all markets had DM45 residue levels higher than recommended, implying that tomato consumers are at high health hazard risk. It is concluded that although treating tomato fruit with DM45 improved some of their quality characteristics, fruit spoilage and microbial growth increased with storage time. The need is to develop IPM systems for reducing DM45 residues on tomatoes, to develop safer methods of preserving fresh tomatoes, and to train growers on the application and use of pesticides to minimize usage.

Post-harvest storage: During studies of moulds and mycotoxins in maize carried out in Mayuge and Kumi Districts of Uganda in 2000 and 2001, it was found that mould infection and aflatoxin contamination start from the farm. This current study revealed that harvest and post-harvest systems of maize practiced by farmers in Mayuge District do not protect maize against mould infection and mycotoxin contamination. Common harvest and post-harvest practices and problems are: All farmers leave maize to dry in the field before harvest with the majority leaving it there for more than three weeks, thus exposing maize to macro and micro loss agents. The majority of farmers dry maize unshelled, without husks, and on bare-ground, thus exposing it to soil-borne moulds including *Aspergillus flavus.* Farmers don't use recommended methods of grain moisture content determination, but use traditional methods like biting and physical observation, thus contributing to unsafe moisture content levels in storage. The majority shell maize by beating, causing physical damage and exposing grains to mould infection and mycotoxins. Some farmers sort maize to remove diseased, broken and discoloured grains. This is a good practice in terms of controlling deterioration agents like moulds during storage. It also reduces chances of consuming mycotoxin-contaminated maize grains. Farmers store maize for 1 - 6 months, which is long enough for the development of aflatoxins. Rodents, insects, fungi and leakage are the most important storage problems of maize in the district. These are related to mould infection and mycotoxin production of the produce. Most of the storage practices and systems don't protect maize against mould infection and multiplication; thus there is a need to train and assist farmers to improve their storage systems to extend the shelf life and quality of their maize.

A study was conducted to establish microflora causing maize ear rots in the field to establish the level of mycotoxins, and to determine the reaction of commercial maize varieties to the two most common agents of maize ear rots, *F. moniliforme* and *S. maydis.* Species of *Fusarium, Aspergillus, Penicillium, Acrimonium, Phomopsis* and *Rhizopus* were identified. *Fusarium* spp and *Aspergillus* spp were the most common moulds, with *Fusarium moniliforme* being the most prevalent species. The mean aflatoxin levels in 'healthy' kernels ranged from 0.6 to 13.5 ppb while in infected kernels it ranged from 2.7 to 35 ppb. The twenty commercial varieties were inoculated at silking stage with *Stenocarpella maydis* and *Fusarium moniliforme* at four different locations to determine the reaction in different environments. *S. maydis* resulted in higher percentage ear rot than *F. moniliforme* at Namulonge and Kamenyamigo but at Kere, *F. moniliforme* was the most severe. The implications are that: a) a large number of fungal pathogens are responsible for causing maize ear rots, b) tolerance of maize genotypes to maize ear rots varies with

season and location, and c) aflatoxin levels vary with the season.

Coffee Wilt (*Fusarium xylarioides*): Lack of knowledge on etiology and epidemiology, of Coffee Wilt Disease (CWD), has prevented the development of effective control measures to combat this important disease of robusta coffee in Uganda. In this report, a detailed study of the CWD causal pathogen, *Fusarium xylarioides*, its pathogenic nature and molecular characteristics, was undertaken to further understand the nature by which infection occurs. The studies indicate that, although no alternate hosts of the pathogen were identified, various transmission avenues are possible. Variation in varietal response to the pathogen was also established. Additionally, there was little variation in the pathogen. This means that breeding strategies against the disease are simpler because only one type of strain has to be addressed. However, pathogenicity tests revealed some differential reactions of clones to the 16 isolates.

Morphological and cultural characters were not effective for characterization of the isolates, though useful for distinguishing *F. xylarioides* from other *Fusarium* species associated with the crop. A more accurate and specific method, e.g. PCR based method, is needed. Seedlings planted in soil sampled from around infected trees showed low infection rates with a very long latent period. However, this can be a significant source of inoculum when seedlings are transported and planted elsewhere. It is important to sterilize soil for nursery use.

Seeds from diseased trees have a low germination rate and poor root system development. Coffee trees infected with the wilt disease should not be used as a source of seed and it is strongly discouraged. Pathogen transmission through coffee husks is possible. Recommendations against use of coffee husks from affected areas may be important in controlling spread of the disease. CWD may be spread through roots of affected plants to nearby non-affected ones. Thus, uprooting and burning may have limited impact as a disease control measure. Successful infection of seedlings by *F. xylarioides* seemed to require presence of wounds in the lower parts of the plants. Wounds created in the collar region or roots during cultivation of coffee could provide entry for the pathogen. Careful weeding or cultivation of the crop to avoid wounding is recommended.

Socioeconomic Assessments of IPM CRSP Technology Development Activities

IPM Technology Dissemination: An assessment of IPM CRSP Uganda site activities completed in 2000 indicated that, although research activities were fully participatory and had positive impacts on farmer knowledge of IPM and crop specific IPM technologies, the number of project beneficiaries was small. As a result, the IPM CRSP Uganda site, in cooperation with the Rockefeller Forum and DIFID, began implementing farmer field training schools (FFS) to reach a larger audience. Through FFS alone the IPM CRSP has reached an additional 330 farmers.

In order to assess the impact of FFS on farmer knowledge and awareness of IPM and cowpea specific IPM technologies, pre- and post-field school tests were administered to 150 participating farmers from six different farmer associations in Kumi and Pallisa districts. A summated ratings scale consisting of four attributes of IPM was used to measure IPM knowledge. Post-test results indicated that the field schools were successful in raising farmer knowledge of IPM as farmers' demonstrated increased knowledge/awareness of each IPM attribute. However, the study also indicated that farmers who attended 10 or more field-school sessions benefited in terms of knowledge gain more than those who attended less than 10 sessions. Part-time or inconsistent participation led to a significant decline in knowledge accumulation and thus benefits.

Similar results were achieved in FFS that focused on groundnut IPM. Baseline information was collected from 180 farmers in the Districts of Iganga, Pallisa, Kumi and Kaberamaido. Farmers participated in 17 weekly sessions during the growing season. Post-test questionnaires were administered at the end of the growing season to evaluate the acquisition and retention of knowledge. Results indicate that farmers who consistently attended farmer field school sessions gained more IPM knowledge compared to those who attended fewer sessions. In general, participation in the field

schools led to higher levels of knowledge of IPM and IPM groundnut technologies.

Considering the logistical and time expenditures for field school implementation, it may be important to obtain some form of commitment from farmers to attend all FFS sessions. Although it may be unrealistic to require small-scale farmers to pay full tuition for FFS, a small partial payment or some other form of in-kind payment may need to be considered.

Technology Transfer and Training Events for the IPM CRSP Uganda Site

- **Geographic Information Systems Training**: ArcView GIS session with eight Makerere University agriculture students, held from 14 to 18 July, 2003.
- **Farmer Field Training Schools**: Held in 6 different districts, focused on cowpea and groundnut IPM practices, with 330 farmers.
- **Striga Management Training:** for approximately 90 farmers in Kumi, Pallisa and Lira Districts**.**
- **Managing Termites with Predatory Ants Farmer Workshops:** Three workshops were held in different communities with 43 people attending, 11 of whom were women.
- **Post-harvest Management Training**: With 10 farmer groups (a total of 200 farmers) in Apac District focused on dehulling and proper storage practices.
- **Pesticide Safety Training:** For 32 district extension agents, stockists and NAADS service providers**.**

Technology Adoption Assessments: A study to assess the adoption of the cowpea IPM package was conducted by comparing 90 participants of farmer field schools (FFS) with a control group of 90 farmers who had not participated in FFS. The cowpea IPM package that had been developed and tested over the previous four years using the participatory research approach consisted of four component technologies: early planting (7-10 days following onset of rains), use of 3 timely sprays (spraying at budding, flowering and podding), correct spacing (60cm X 20cm), and use of an improved variety (MU-93 Large White). As expected, FFS participants adopted more of the package components than non-participants and participation was the most important factor in explaining adoption. The most adopted technology by participants was the use of three sprays followed by correct spacing, and use of an improved variety (M.U.93). The least adopted component technology was date of planting. However, there were only significant differences between participants and non-participants in the adoption of the improved variety and use of correct spacing. Non-participants also used 3 sprays, concentrating them during the first stage of crop development (before flowering). Although more participants (32%) than non-participants (18%) had planted early, non-adopters of this recommendation among both groups indicated that their ability to plant cowpea early was hindered by lack of access to labor and/or animal traction for land cultivation. None of the non-participants adopted the improved variety whereas 43% of FFS participants adopted the improved variety, and 54% of the participants adopted correct spacing compared to only one non-participant.

In another adoption study, factors affecting the adoption of eight IPM practices on sorghum, cowpea and groundnuts in Kumi District in eastern Uganda were evaluated. Data were collected from 212 randomly selected farmers in April 2002. One hundred and four women and 108 men were surveyed. The adoption of IPM practices was most strongly affected by whether the farmers had: participated in any on-farm trials, had any kind of pest management training, and/or had obtained agricultural information from Makerere University researchers. Gender, size of farm, and the level of education did not affect the adoption of IPM practices.

Economic Assessments

Economic Evaluation of *Striga* Management Options on Sorghum: Data were obtained from the experiments involving intercropping Seredo an improved sorghum variety, with trap crops including cowpeas, Bambara nuts, silver leaf desmodium and *Celosia argentia* and use of fertilizer. Intercropping sorghum with Bambara nuts (net benefit of U Shs 202,250) and cowpeas in the ratios of 1:1 (net Benefits of U Shs 68,850) and

silver leaf desmodium in the ratio 1:2 (net benefits of U Shs. 73,300) were found to be the most economically viable *Striga* control option. The benefits are two fold: Silver leaf desmodium is beneficial as a pasture crop and Bambara nut and cowpeas are edible legumes. Use of these trap crops could cheaply reduce the *Striga* infestation on farmers fields, increase yields of sorghum and improve soil fertility in the long run.

Economic Evaluation of Field Management Practices of Podding Pests of Cowpeas on Bruchid Carryover in Storage: Data for this study were obtained from the experiments conducted by biological scientists in Kumi and Pallisa districts in Eastern Uganda. Data were collected on various aspects including seed rates, field prices, field costs such as planting costs, weeding costs, and costs of harvesting, winnowing, threshing and marketing. Treatment 3, which involved spraying five times with cypermethrin and then tobacco aqueous formulation was the only treatment that produced higher net returns (U Shs of $ 174,700) relative to the control, which involved no sprays (U Shs 144,000). It should be pointed out that Treatment 3 involves more financial risk than the control with variable costs exceeding those of the control by U Shs 583,500.

Optimal Input Use Levels and Indicators of IPM Technology Uptake in Maize Production: Primary data for the study were collected using a structured questionnaire and this was personally administered to 180 respondents who were randomly selected from the districts of Iganga, Mayuge and Kamuli. Maize production functions were estimated. The most significant factors affecting production were capital (value of seed and fertilizer), labor, income, and districts (Iganga and Kamuli) for all the respondents. Other variables like age of the farmer, frequency of extension visits, membership in farmer organizations, gender, and whether farmers had participated in IPM work did not significantly affect production. Overall, capital (value of improved seed and value of fertilizer) and off-farm income were most limiting in maize production.

Gender and Pest Management: The increasing number of female headed households in Sub-Saharan Africa requires that gender based knowledge and perceptual differences be assessed and incorporated into agricultural research and extension program delivery if these programs are to have meaningful and sustainable impacts. However, there was little evidence from 200 male and female respondents (52% female; 48% male) working with the IPM CRSP in Eastern Uganda to support assertions in the literature that women play a predominant role in pest management. Pest management decisions appear to be made by the household head, whether that person was male or female. There was general agreement between male and female respondents that although women were as likely to indicate that they were having their fields sprayed with pesticides, men were more likely to be doing the actual pesticide application. Men appeared to have greater access than women to alternative and exogenous sources of information on pesticide usage. Women were significantly more knowledgeable of the four attributes of IPM, particularly, possible negative effects from pesticide use.

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Overview of the West Africa Site in Mali

Keith M. Moore, Site Chair (Virginia Tech); Kadiatou Touré Gamby, Site Research Coordinator (Institut d'Economie Rurale); Bouréma Dembélé, Site Administrative Coordinator (Institut d'Economie Rurale)

The Collaborative Program

The IPM CRSP research program of the West Africa Site in Mali is carried out through a multi-disciplinary team of collaborating scientists based at five U.S. and four Malian institutions. The four Malian institutions playing a leading role are the agricultural research institution *Institut d'Economie Rurale (IER*), the extension organization *Opération Haute Vallée du Niger (OHVN)*, the toxicology laboratory of the *Laboratoire Central Vétérinaire (LCV)*, and the *Institut Supérieur de Formation et de Recherche Appliqué (ISFRA)* of the *Université de Mali*. The West Africa Site in Mali is based at the *IER*. *IER* provides the administrative and research coordination as well as leading scientists for the research activities, contributing expertise in entomology, plant pathology, economics, and weed science. IPM CRSP collaboration constitutes a key element in *IER*'s long-term plan as defined within the framework of World Bank financing.

The IPM CRSP Project in Mali is supervised by two coordinators. Dr. Kadiatou Touré Gamby, Head of Fruit and Vegetables based in Sotuba, ensures the scientific coordination of the project, and Dr. Bouréma Dembélé, Scientific Director for IER and Head of the Weed Science Program, ensures the administrative coordination of the project. The coordination of IPM CRSP activities at the research station of Cinzana (CRRA/Niono) is carried out by Mr. Mohamed N'diaye, Entomologist for Millet and Sorghum, and Mr. Sériba Katilé, Plant Pathologist for Millet and Legumes. The IPM CRSP collaboration with *OHVN* is ensured by Mr. Issa Sidibé, Section Head for Research and Development Linkages. *OHVN* works with the private sector in production and marketing of export horticultural crops, including green beans exported to France and hibiscus exported to Senegal, Germany, and the United States. Pesticide residue evaluation activity for exportable products (green beans, tomatoes) financed by the USAID Mission in Bamako is conducted in collaboration with the Toxicology Laboratory of *LCV* under the direction of Dr. Halimatou Koné Traoré. *LCV* is taking the lead in developing a Quality Assurance System for horticultural produce. *ISFRA* provides training for master's students working on IPM CRSP project activities.

In the United States, five institutions contribute to the collaborative research program: *Purdue University*, contributing expertise in vegetable IPM (Dr. Rick Foster); *North Carolina Agricultural and Technical University*, contributing expertise in economics of small-scale producers, including women's horticulture and export markets (Dr. Anthony Yeboah); *Montana State University*, contributing expertise in post-harvest assessment, natural pest control products, and technology transfer (Dr. Florence Dunkel); *University of California-Davis*, contributing expertise on viral diseases in tomatoes (Dr. Robert Gilbertson); and *Virginia Tech*, contributing expertise in weed science, pesticide residue analysis, and quality assurance (Dr. James Westwood, Dr. Don Mullins, Dr. Patricia Hipkins and Jean Cobb). *Virginia Tech* also provides leadership in the person of the Site Chair and Rural Sociologist (Dr. Keith M. Moore).

In IPM CRSP Year 10, the fifth year of Phase II, the Mali site has consisted of participatory on-farm research on IPM technologies for the management of disease and insect pests of the most important peri-urban horticultural crops (green beans, for export) and the tomato (largely for domestic consumption and potential canning). In the first years of Phase II research on horticultural export crop pest management, IPM components were developed independently to provide the basis for subsequent combination into packages that address different pest problems simultaneously. This research is complemented by on-station research on biological control of the key insect pests, and the

conclusion of innovative approaches to management of *Striga* parasitic weed on millet and sorghum, the principal cereal crops of Mali. The second stage of Phase II research focuses on the testing of pest management techniques as integrated packages, and the third stage involves disseminating farmer-tested IPM packages for each horticulture crop in the program. Men and women from twenty-one villages are participating in village-level FFS (farmer field school) dissemination of the integrated green bean pest management package. Viral problems in tomatoes arising in many producer villages have returned researcher emphasis to stage one priorities for tomatoes: diagnosing the type of viral infection, testing virus resistant varieties and identifying improved plant protection practices.

In addition, these research efforts serve to support the development of a system to reduce pesticide residues on agricultural products through the new *Environmental Quality Laboratory (EQL)* of the *Central Veterinary Laboratory (LCV)*. Rational use of pest control measures may include synthetic pesticides. Consequently, pesticide residue analysis allows for the provision of information on both the current performance and potential improvements of the system. Combined with on-farm research, pesticide residue analysis aids in the development of IPM technologies for quality produce verified to meet international food safety standards and residue levels, and ensure the safety of farmers using pesticides.

Technology Transfer

Since its creation, the IPM CRSP has worked with the *OHVN*, which has, as a principal objective, ensuring food security and the diversification of farmer incomes. The *OHVN*'s zone of intervention is the upper Niger River basin, a region where market-garden production is conducted within a short distance of the international airport. Through its Agro Business unit, the *OHVN* ensures the connection between producers and wholesalers, including exporters such as *Flex Mali* and *Mali Première*, both exporters of green beans. In the last few years, green beans have become one of the principal export crops towards Europe and this has allowed many small farmers to engage in export agriculture. In *OHVN* zones, green bean production was 124 tons in 2000 with 95 % destined for export and 5% sold on the local market.

The IPM CRSP has collaborated with FAO in the development of didactic materials designed for extension agents and farmers through technical and financial support. For improved diffusion of the technologies developed, the IPM CRSP also collaborates with *PRONAF Mali* (*Project Niébé Africa*), financed by the *International Fund for Agricultural Development (FIDA)* using the Farmer Field School concept. During the past two years farmer field schools have been conducted with both men and women farmers in twenty-one villages. An evaluation of this approach found that not only were men and women exhibiting improved farming practices and yields, but that their non-FFS participant neighbors were also benefiting.

The program carried out through the IPM CRSP focuses on the major thrusts of *IER*'s ten-year strategic plan. This work plan is re-examined annually during meetings of the *Regional Users Committee (CRU)* and the *Regional Technical Committee (CTR*). At the end of each season, research results are reviewed and plans for the subsequent year are discussed with the farmers.

IPM Constraints Researched

At the beginning of the IPM CRSP Phase II, a hundred green bean farmers were interviewed and agreed that insects and diseases constitute the primary constraints for green bean production from seeding to harvest. Harvest losses were very high, on the order of 4000 kilograms per hectare, amounting to a loss of 160,000 Francs CFA. In addition to the loss in weight, there is also the decline in bean quality caused by insects (such as borers) because the presence of a single damaged pod can result in the rejection of an entire carton destined for export. The principal pest problems for green beans during the past few years have been thrips, whitefly (*Bemisia tabaci*), pod borers, and soil borne diseases.

Among the most frequently cited constraints identified during a recent Participatory Assessment were: (1) the lowering of the water table of the

wells which decreases the potential for increasing production; (2) attacks of birds which damage pods causing significant losses of production; (3) the problem of acquisition of certain inputs, such as plastic mulching covers and petroleum jelly; and (4) delay in the payment of the producers. However, more serious has been the weakening of Malian market position in the international market at Rungis, France. Malian exports have dropped over the past couple of years due to poor transportation infrastructure (insufficient space on daily flights and lack of a cold chamber at the Bamako airport). Consequently, one of the major constraints in market chain development, is the need for producers to adapt to changing market and regulatory demands.

Producers have identified the major constraints for tomatoes as being diseases attacking the plants and the fruits: viruses, *Fusarium*, soil borne diseases, fungal and bacterial diseases. However, diagnosis of tomato production constraints has been rapidly and more precisely advanced this year using biotechnology (PCR) due to support from the USAID Mission in Bamako. The most important constraint has been two whitefly (*Bemisia tabaci*)-transmitted geminiviruses, the Tomato Leaf Curl Virus (TLCV) and the Tomato Yellow Leaf Curl Virus (TYLCV). The combination of these two viruses has brought whole villages to cease production of tomatoes.

In garden plots throughout south-central Mali, C*yperus rotundus* has proven to be the most persistent and devasting weed. Other yield reducing weeds include *Pilea microphylla*, *Cynodon dactylon*, *Imperata cylindrica*, and *Commelina benghalensis.* The parasitic weed *Striga* remains one of the major constraints to millet and sorghum production in sub-Saharan Africa.

Institution Building

The human resource development strategy prepared for the West Africa Site is long term in perspective, assuring a breadth of skills and capacities available for IPM research into the future. This multi-faceted program depends on the *University of Mali* for the training of two master's degree students: Daouda Dembélé, in weed science, and, Sidiké Traoré, in entomology. Moussa Noussourou, in entomology at the *University of Mali*, has just begun working on his Ph.D. program under the direction of Rick Foster, Entomology/*Purdue*, and Bob Gilbertson, Plant Pathologist/*UC-Davis*. Safiatou Dem is completing her masters degree in Biochemistry at *Virginia Tech* under the direction of Don Mullins, entomologist. Bright Abonuhi, a Ghanaian student, completed his masters' degree in economics at *North Carolina A&T* with Anthony Yeboah, agricultural economist.

The Farmer Field School Program continued on green bean production for export and involved the training of 174 men and 151 women farmers in 21 villages led by previously trained IER and OHVN FFS trainers and farmer-trainers (from previous trainees, including one woman).

Short-term training in the U.S. involved Moussa Noussourou (entomology) for two months at *UC-Davis*, Haoua Sissoko (gender specialist) for two weeks at *Virginia Tech*, and Penda Sissoko Sow (agricultural economist) for two weeks at *North Carolina A&T*.

Institutional strengthening is reinforced by frequent opportunities for one-on-one collaboration in the planning and conduct of research activities. Nine trips were made to Mali by U.S. scientists and one by the Central American Site Coordinator from Guatemala to collaborate with *IER* and *LCV* scientists and *OHVN* partners. Collaboration involved issues including a survey to investigate establishing a TYLCV host-free period (Dr. Moore), assessment of weeds in peri-urban horticulture (Dr. Westwood), drafting entomology papers (Dr. Dunkel), tomato disease investigations (Drs. Gilbertson and Foster), marketing chain analysis (Drs. Moore and Sanchez), toxicology laboratory development (Drs. Mullins and Cobb), and quality control assurance and pesticide usage and application (Drs. Mullins and Hipkins).

On the Malian side, five visits were made to the U.S. and two trips to France by Malian scientists. Dr. Gamby and Issa Sidibe visited the U.S. for the annual planning meeting and discussions concerning the development of a pesticide safety program for horticultural farmers. Moussa Noussourou, Penda Sissoko Sow, and Haoua Sissoko worked on entomology, agricultural

economics and social science, respectively. Dr. Traoré and Mr. Sidibé (DGRC) visited the Pesticide Residue Laboratory in Massey, France, COLEACP, and the International Market in Rungis.

The Malian Government supports *IER's* IPM Program by paying salaries of the researchers and technicians, and supplying equipment and supplies (vehicles, offices, laboratories and experimental fields, etc.). Additional support for institution building has come from the IPM CRSP in the form of two computers, for the socio-economic and weed programs at the CRRA/Sotuba research station of *IER*. In addition to this material support, the IPM CRSP has made an important contribution to research in Mali by establishing and maintaining a strong multi-institutional and pluri-disciplinary team in collaboration with farmer associations.

Networking

The core mechanism for in-country diffusion of research results depends on the relationship between *IER* and *OHVN* in the peri-urban horticultural regions. This relationship is built on the work of *IER/OHVN* liaison officer, Issa Sidibe. The network extends from field agents in the peri-urban horticultural regions encountered frequently in the field (by Pat Hipkins, Mme Gamby, and Moussa N'diaye). Dr. Dunkel is developing collaborative relations with the *US Peace Corps-Mali* (Ag Sector) and *World Vision-Mali* (Bla Region) as a means for transferring Phase I IPM CRSP technologies to farmers.

IPM CRSP research results have been presented at the Regional Technical Committee (CTR) meeting at Sotuba (May 2003), at the Regional Users Committee (CRU) meeting at Sotuba (March 2003) and to the IER Program Committee (June 2003).

Mme Halima Traoré (LCV) and Demba Sidibé (DGRC) of the Malian Ministry of Agriculture, Livestock and Fisheries visited the Pesticide Residue Laboratory at Massey, France, the Agence Française de Sécurité Sanitaire des Aliments (AFSSA), and the Liaison Committee for the promotion of horticultural exports Europe, Africa, Caribbean and Pacific (COLEACP). Working relations were established with Bernard DeClerq, Chief of France's Pesticide Residue Laboratory, and with Catherine Guichard (General Secretary), Roland Levy (chemistry/regulation expert), and Harry Lugros (Training) of COLEACP concerning the Pesticide Initiative Program (PIP) and the possibilities of collaboration with this program in Mali.

Pesticide safety education efforts included a two-day pesticide safety Training-of-Trainers workshop for FFS trainers as well as the delivery and evaluation of instructional, lesson plans and hands-on demonstration materials. Topics presented at the training session included an overview of pesticide safety, small group workshops, and a demonstration of pesticide handling and exposure. In addition, the participants assessed lesson content and presentation styles with regard to what modifications, if any, should be made before using them to instruct Malian farmers. Workshop participants included representatives from the *Institut d'Economie Rurale's* CRRA/Sotuba, the *Office de la Haute Vallée du Niger* (OHVN), and *Direction Générale de la Réglementation et du Contrôle* (DGRC). There is considerable demand for extending this training for the DGRC.

Regional networking is built around several foci. Dr. Moore met with Amadou Diarra of the *Institut du Sahel (INSAH)*) to discuss farmer and vendor training in safe pesticide use and IPM technology for horticultural export production. Dr. Diarra is the *CILSS* liaison for harmonization of pesticide use. Dr. Traoré is maintaining contacts with Dr. Abdoulaye Niassy, *DPV/Sénégal* and the USAID/Washington-funded Biopesticide Development Project. Dr. Traoré has continued collaboration with Dr. Ardjouma Dembélé of *LABECO* in Ivory Coast, particularly in terms of developing improved supply sources for laboratory chemicals.

Research Accomplishments

Weed Control Strategies for Tomato and Green Bean Production

Research this year focused on use of mulch as a component of weed control in tomato. Use of locally available straw as a mulch material provided effective control of *C. rotundus* and other hard-to-

control weeds. Mulch depths of 15 cm reduced weeds and increased crop yields to levels similar to the current practice of frequent hand weeding. These results are consistent with our previous work in green beans. The use of burned mulch material was also studied. Burning crop residues on the soil surface was not effective as a sole weed control method, but when combined with use of mulch it decreased weed numbers and increased yields relative to the current farmer practices. These techniques provide simple, affordable, non-chemical weed control that results in yields that meet or exceed current levels.

- Straw mulch covering plots to a depth of 15 cm provides excellent control of many troublesome weeds (including *Cyperus rotundus*) in tomato plots.
- Burning mulch on the soil surface prior to planting can enhance weed control when combined with use of mulch during the growing season.

Identification and Management of Tomato Diseases

Polymerase chain reaction (PCR) tests determined that the diseases affecting tomatoes were not caused by phytoplasma, but due to geminiviruses. DNA sequencing determined that one virus was most common, the Tomato Leaf Curl Virus (TLCV). A second virus was also detected in the samples, the Tomato Yellow Leaf Curl Virus (TYLCV). A DNA probe and primers have been developed to facilitate identification of the virus in both vectors (whiteflies) and in host plants. PCR equipment has been purchased and is being delivered to CRRA/Sotuba for installation in a new biotechnology diagnostics laboratory.

A Malian scientist, Moussa Noussourou has completed a two-month laboratory training on using the PCR with Dr. Gilbertson at UC-Davis. His training involved methods for the detection and identification of geminiviruses including sap-transmission, DNA extraction, PCR detection, cloning of PCR-amplified geminivirus fragments, sequence analysis and comparison. Moussa Noussourou's Ph.D. research will focus on the implementation and evaluation of a host-free period in the Baguineda Irrigated Perimeter.

A preliminary survey of producers in Baguineda determined that farmers were prepared to make adjustments in their production systems to combat the TLCV. The analysis suggests, however, that the farmers could not distinguish between the geminivirus (cause of the disease) and the whitefly (vector of the disease). Clearly, training may be in order. The household survey will provide more detailed information about how the host-free period can be established.

Tomato germplasm with geminivirus resistance has been identified for testing which includes varieties from Heinz Seed Co., Seminis Seed Co. and AVRDC. In trials held at Sotuba and Katibougou, three imported varieties have already proven to be resistant to geminivirus attacks and double production: H6503, H6703, and F1 Mongal.

- Two geminiviruses have been identified through DNA sequencing as producing the diseases destroying Malian tomato production.
- Three varieties have been identified as resistant to TYLCV/TLCV and are capable of doubling production levels over the current standard resistant variety (Roma).

Evaluating Farmer Field Schools

Currently, farmer field schools (FFS) for both men and women on green bean farming are being implemented in 21 villages just outside Bamako. In spring 2003 a survey was prepared and carried out in three of these villages – Dialakoroba, Sanambélé, and Tamala – to assess the impact of these schools and the adoption rates for both FFS participants and non-participants of the techniques taught in the schools.

The results show that the FFS had a large and positive benefit on both participants and non-participants. As for the latter, since women were added to the schools, both sexes have become aware of the content of the schools. Farming practices have greatly improved, both generally and in regard to the issues of pests and diseases. Farmers are very happy to have learned new techniques that enable them to improve their yields. Women are glad to be able to farm without having

to wait for their husbands to help them, now that they not only do not need to use dangerous sprays but also have the technical know-how to carry out all aspects of vegetable cultivation. Non-participants have also absorbed a considerable amount of the information and have improved their farming techniques.

- Adding women's FFS has made a significant impact on the village as a whole.
- The result of this has been significant adoption rates of IPM techniques over the whole village.

Economic Analysis of IPM Packages on Green Bean Production

Statistically significant performance of a particular technology does not always translate into economic benefits to its user. It is, therefore, necessary to analyze how agronomic benefits translate into socio-economic benefits since these ultimately determine the adoptability of the proposed technology. The adoption of IPM technologies will depend, not only on their performance in the field, but also on the costs and returns associated with them.

IPM technology of using insect traps alone was superior to both the use of insect traps and neem extract and the farmers' practice. However, neither of the two IPM technologies proved superior to either the single or double application of Decis. Nevertheless, the use of insect traps alone yielded a net profit of 1,554,789 FCFA or $2,221 per hectare (US$1= 700 FCFA), while the use of insect traps plus the application of neem extract yielded 1,526,516 FCFA or $2,181 per hectare. Both figures are significantly higher than the corresponding figures for the farmer's practice of three applications of Decis, plus an application of chemical fertilizer and organic manure, which were 947,013 FCFA or $1,353 per hectare. The profitability for single and double applications of Decis was also lower than that for both IPM technologies: 1,304,564 FCFA ($1,864) and 1,479,987 FCFA ($2,114) per hectare respectively.

- The use of insect traps alone yielded a marginal rate of return of 120% over double application of Decis and 321% over a single application of the chemical.

Strengthening Stakeholder Relations

IPM CRSP interventions need to be evaluated from both a bio-physical and a social perspective. Given the complexity of factors influencing agricultural production, this multidisciplinary research activity has aimed to triangulate on the factors influencing farmer green bean production techniques and the impact of IPM CRSP technologies introduced into targeted villages by expanding the range of analysis downstream in the marketing chain to the green bean exporters. A lack of confidence of green bean exporters in the brokers at the Rungis market in France led this research to examine the marketing chain from the perspective of the green bean importers. Importers are trying to establish credible relations with wholesalers and retailers. Their concerns with respect to Malian exporters are to have a stable and sufficient supply of green beans during a three-month winter window. Overall, they have been pleased with the quality of Malian green beans. There have been no rejections due to pesticide residues. Their chief concern is that shipment delays lead to deterioration in product quality.

- There is a potential to develop and exploit a market for "organically" grown green beans in Mali for exportation to France. However, Mali is losing market position due to poor transportation infrastructure.

Environmental Quality Laboratory and Pesticide Safety Education

Technical training of the staff at the Environmental Quality Laboratory (EQL) continued with attention on optimizing pesticide methods, use of instrumentation, and preservation of electronic records. Pesticide applicator safety and quality assurance training expanded to include OHVN field agents and crop exporters. Other Malian agencies requested similar training. Initial stages for preparation of a pesticide safety training "flip book" included a review of text and illustrations of an existing U.S. EPA PSE manual. A Malian graduate student working on an M.S. degree at Virginia Tech successfully completed the majority of required courses and has begun environmental monitoring

research after a farmer pesticide survey and soil sample collection in Mali during summer 2003. Additional measurement of water quality parameters (pH, turbidity) from village wells reinforces earlier impressions that especially turbidity may reduce the efficacy of pesticides applied to horticultural crops. A study tour of an accredited pesticide testing laboratory and the Rungis import market in Paris provided useful insights for the EQL and DGRC representatives from Mali who have some responsibility for evaluation of vegetable quality prior to export to Paris.

Preliminary data suggest that water quality parameters (pH and turbidity) of village well water may affect pesticide efficacy.

Innovative Technologies for *Striga* Management

We have continued research into new approaches for limiting *Striga* damage to sorghum and millet crops in Mali. This work, initiated in 1999, is testing the hypothesis that small quantities of herbicides absorbed into crop seeds can serve as a deterrent to early parasitic attachments of *Striga*. With the data from 2002, this research project had completed sufficient experimental trials and replications to justify publication of our results. This project has been complicated, involving several herbicides and two different crops in addition to variations in environmental factors that forced us to repeat some trials three or four times. Nevertheless, we conclude that the herbicide 2,4-DB has potential as a seed treatment for *Striga* control. Thus, a major activity for this year was data analysis and the preparation of a manuscript. This manuscript was submitted to the journal, Weed Research. The next phase of this project is to focus on methods to optimize the effect of 2,4-DB by identifying techniques to reduce crop toxicity while maintaining the inhibitory effect on *Striga*.

- The herbicide 2,4-DB shows promise as a seed treatment in sorghum to reduce parasitism by *Striga*.

Overview of the Central America Site in Guatemala and Honduras

Stephen C. Weller, Site Chair (Purdue University); Luis Calderón , Site Coordinator (ICADA, Guatemala)

The Collaborative Program

The IPM CRSP Central American Site had an exceptionally productive program agenda in Year 10. The site operates through an active site committee structure, with Guatemala as the prime site for Central America. Ing. Luis Calderón (ICADA) has replaced Dr. Guillermo Sánchez as the regional site coordinator for Central America. The Regional Site Committee is comprised of Luis Calderón and Guillermo Sánchez (ICADA), Jorge Sandoval (UVG), Danilo Dardón, (ICTA), Jorge Mario Santos (MAGA), Luis Caniz (APHIS-IS), Linda Asturias (ESTUDIO 1360), and Maria Mercedes Doyle (ZAMORANO). The U.S. researchers that collaborate with the regional site committee and provide research support, technical support, and program coordination include: Drs. Stephen C. Weller, U.S. Site Chair; C. Richard Edwards and Ray Martyn (Purdue University), Sarah Hamilton (Adjunct Professor-Virginia Tech), Judy Brown (University of Arizona), and Michael Deom (University of Georgia). The overall Central American site activities in Year 10 were funded through USAID IPM CRSP under subcontract with Virginia Tech.

Preliminary research agendas and budgets for the Central America Site are established during the annual Technical Committee meetings. These broad research agendas are then presented to the Site Committee for review, discussion, and prioritization of specific research activities for the year following the participatory format of the IPM CRSP. The Site Committee meets monthly to discuss research progress and make consensus decisions on any revisions. Each collaborator and/or collaborating institution has the opportunity throughout the year to request revisions in previously approved research agendas and budgets. Such revisions require Site Committee consensus.

An MOU was established during Year 10 with the Honduran Foundation for Agricultural Research (FHIA). FHIA and ZAMORANO were the principal regional collaborating institutions outside Guatemala in Year 10. Substantive discussions were conducted with the Honduran and El Salvadoran Ministries of Agriculture to lay groundwork for future collaboration with IPM CRSP and site expansion.

In Guatemala, APHIS and AGEXPRONT continued to provide strong collaboration in the development of IPM / Integrated Crop Management (ICM) strategies for reducing pesticide use, increasing product quality, and improving the performance for achieving safer food supplies in the NTAE sector. APHIS-IS and MAGA (Ministry of Agriculture, Guatemala) continued to provide collaborative leadership in the development and institutionalization of preinspection programs in Guatemala. GOG grants to IPM CRSP researchers at Universidad del Valle, ICADA and AGEXPRONT provided funds for community level research transfer activities and training, including field demonstrations. ICTA and UVG have continued to collaborate in testing and revising IPM CRSP production strategies for improved pest management in snow peas (leaf miner), tomatoes (whitefly), broccoli (*Plutella xylostella*), and papaya (papaya ringspot potyvirus). ESTUDIO 1360, in collaboration with Dr. Sarah Hamilton, contributed substantively to research activities that evaluated the socioeconomic impacts of NTAE production at the community and household levels.

IPM Constraints Addressed

Institutional policies

Science-based production and preinspection policies that lead to reduced pesticide usage and decreased product rejections at U.S. ports-of-entry continue to be the major focus for resolving some

of the more important institutional constraints in Central America. In Guatemala, MAGA endorsed these efforts in Year 10 through programs and national policies that encouraged substantive adoption at the national level. Private sector involvement has centered on the development of a regional consolidation and distribution center in San Cristobal Totonicapan, under the direction of the Asociación of Fruticultores Agrupados (FRUTAGRU), and on the development of pre-inspection manuals for NTAE crops, specifically snow peas. GOG initiatives to revise policies commensurate with the demands of a more competitive marketplace in the NTAE sector are now receiving serious consideration.

The need for continuity and enforcement of public and private sector policies such as credit availability at the producer level continues to influence NTAE development in Central America, including the implementation and institutionalization of performance-proven IPM/ICM production practices and certified pre-inspection programs. In Guatemala, the GOG continued a proactive role. AGEXPRONT and ICTA, in collaboration with the IPM CRSP, have continued to play a central role in developing more proactive production and post-harvest policies that serve to enhance performance in the NTAE sector.

Technology Transfers

The IPM CRSP continued transferring specific production practices literature on biorational IPM/ICM technology to NTAE producers and field technicians in Year 10 which helps many small independent NTAE producers reduce reliance on chemical control practices and use of unregistered pesticides for insect and disease control. This training is gradually allowing more IPM CRSP approved pest management information to be transferred through grower workshops, technician seminars, and field demonstrations to the actual practitioners. These technology transfer and field demonstration activities will be enhanced as the GOG accelerates program initiatives in preinspection and grower certification. ICTA, AGEXPRONT and PIPAA (Integrated Program for Protection of Environment and Agriculture, GOG) played important roles in these training and technology transfers. ICADA is preparing a pre-inspection manual for snow pea producers.

Research Capacity

A “critical mass” of trained field technicians has been assembled who are capable of addressing pest management problems using applied science-based protocols and approved IPM/ICM practices developed and transferred by the IPM CRSP. AGEXPRONT and ICTA, in collaboration with IPM CRSP researchers, have played an important role in achieving these results.

The IPM CRSP socioeconomic research activities, under the leadership of Dr. Sarah Hamilton and her collaborators at ESTUDIO 1360, have included quantitative assessments of socioeconomic benefits in NTAE producer households. This research has continued to provide excellent documentation needed for strengthening the policy and program commitments from the GOG, AGEXPRONT, and other private sector collaborators to small farm households. Over two-thirds of the NTAE households report that they have improved quality of life since 1980, including housing, health care, education, and nutrition. NTAE earnings enabled 39 of 45 individuals surveyed to buy land, which resulted in a modest deconcentration in land distribution over the last 20 years. These findings clearly helped the GOG make positive determinations in providing funds to support the development of the first grower-based supply consolidation and preinspection center in the NTAE sector (FRUTAGRU center). The IPM CRSP will play an instrumental role in training and technology transfer as additional preinspection centers are developed.

Research collaboration with the University of Georgia, AGEXPRONT, and APHIS helped resolve the ringspot potyvirus problem in papaya in Year 9 through Year 10. This, coupled with the IPM CRSP/APHIS supporting documentation to achieve clearance for papaya into U.S. ports-of-entry, provide the basis for significant NTAE trade expansion in the future once commercially acceptable papaya cultivars are developed.

Institution Building

The Government of Guatemala, through MAGA and ICTA, continued to support the IPM CRSP's overall objectives for strengthening scientific capacity and market-focused planning in the NTAE sector. These institutional linkages continue to be among the most important factors in moving the IPM CRSP research and development agenda forward in Central America. The continued GOG commitment provides clear evidence of the IPM CRSP's role in institution building in Central America. Institutional collaborations with FAS, APHIS, and FAO have been critically important in the past in helping develop additional program funding and capacity for the IPM CRSP. USAID Mission's commitment to microenterprise financing in Guatemala is a cornerstone for the institutionalization of greater access to credit among small NTAE producers which will remove a major constraint to NTAE expansion and the implementation of biorational production programs.

During Years 9 and 10, institutional relationships and research capacity were strengthened in Honduras. Discussions between the IPM CRSP and the Ministry of Agriculture, FHIA and Zamorano resulted in the finalization of an MOU between the IPM CRSP and the GOH, and the award of a $100,000 research grant (FAS/GOH) to strengthen research collaboration in resolving the disease problems associated with virus pathogens in NTAE crops.

The IPM CRSP in Central America continues to place a high priority on strengthening the institutional capacity of collaborators and collaborating institutions. IPM CRSP scientists in the United States have given high priority to strengthening institutional capacity in research, technology transfer, and program implementation. A visit to Honduras and El Salvador during Year 10 included discussions regarding future collaborations between the IPM CRSP and the Ministries of Agriculture in each country.

Student Training

James Julian, a U.S. citizen, completed his Ph.D. under the direction of Dr. Glenn H. Sullivan at Purdue University. His research and training focuses on the impact of non-economic constraints to trade in the NTAE sector of Central America, including food safety and regulatory compliance issues. His dissertation is titled "Assessment of the Impact of Import Detentions on the Competitiveness of Guatemalan Snow Peas in U.S. Markets".

Carlos Mayen, a native Guatemalan, completed his Master's Degree under Dr. Stephen C. Weller in the Horticulture and Landscape Architecture Department at Purdue University in May, 2003. His research and training is in biorational pest management strategies for Central America NTAE crops. His thesis title is "Soil Weed Seed Bank Dynamics in Tomato/Soybean Rotation".

Carlos Mauricio Caballero, a student from the National University of Agriculture, conducted his undergraduate research project working on the collection and testing of the samples at FHIA's Plant Pathology Laboratory. Dr. Jose Melgar was his advisor at FHIA and the title of his research thesis is "Identificación y distribución de enfermedades virales que afectan los cultivos de hortalizas de la familia Solanaceae y Cucurbitaceae en Honduras".

Networking

Collaboration with APHIS-IS in the development and testing of preinspection programs has helped to further expand the IPM CRSP networking activities in Year 10. This collaboration was strengthened through activities associated with USDA's formal approval of Guatemalan papaya into U.S. markets, and will allow expanded program development of the Petén Region for papaya production.

Private sector grower-shippers and shippers of NTAE crops that are participating in the IPM CRSP-lead initiative became important "technology transfer agents", potentially reaching nearly 13,000 small farm producers, field technicians, and community leaders throughout Guatemala and Central America. This networking activity will continue to be important as the GOG implements regional supply consolidation and preinspection centers, and institutionalizes preinspection protocols and policies.

Networking activities at the district and community levels were expanded in Year 10 as additional households in the Chimaltenango District were surveyed in the socioeconomic assessments. Overall, the IPM CRSP has networked with over 40 communities throughout Guatemala. These collaborations serve as the basis for continuing research and outreach activities. In addition, gender and socioeconomic impact studies were conducted at the community level in Guatemala. This networking activity has greatly enhanced the socioeconomic knowledge base of the IPM CRSP, and has generated important gender, household, and NTAE impact conclusions for publication.

Training seminars for NGOs, independent private sector crop management technicians, and PIPAA personnel focused on the transfer of IPM CRSP pest management strategies and preinspection performance protocols. All training seminars were supplemented with published research materials and user manuals developed by ICTA in collaboration with AGEXPRONT and IPM CRSP researchers.

Institutional networking activities continued in Year 10 as preinspection policies in snow pea were institutionalized for implementation by the GOG. ICTA, ICADA, MAGA, APHIS, and AGEXPRONT continued to play important collaborative roles in preinspection research, development, and implementation. In addition, PIPAA, a joint MAGA/private sector entity, was commissioned by the GOG to handle preinspection program implementation, compliance, and enforcement in Guatemala's NTAE sector with assistance in manual preparation by Luis Calderón, IPM CRSP Central American Site Coordinator. This important networking activity required a substantive commitment from the IPM CRSP in training and knowledge transfer.

The IPM CRSP strengthened networking activities in Honduras in Year 10. The former Minister of Agriculture, Guillermo Alvarado Downing, had requested in Year 8 an IPM CRSP-developed research proposal to address the issue of plant virus pathogens that cause serious damage to the melon crop in Honduras. A GOH MOU was then signed with the IPM CRSP in Year 9. Melons, particularly cantaloupe during the period January through April, comprise Honduras' most important NTAE crop. However, plant virus diseases currently threaten nearly 11,000 acres of melon for export to the United States valued at over $24 million USD. The IPM CRSP, under the leadership of Drs. Ray Martyn at Purdue University and Maria Mercedes Doyle at Zamorano, responded to Minister Alvarado Downing's request for a research proposal to address these plant disease problems. The proposal was approved and the Honduras IPM CRSP collaborators received $100,000 USD from the GOH late in Year 9 and work continued in Year 10.

In August, IPM CRSP representatives (S.C. Weller, L. Calderón and G. Sánchez) visited Honduras and El Salvador to discuss research needs in IPM and potential for future collaboration between the IPM CRSP and Honduras and El Salvador. Useful discussions were held with representatives of each Ministry of Agriculture and site visits were made to view research farms and grower locations. There are many common interests for future site expansion into Honduras and El Salvador and a great interest in NTAE crop expansion based on sound IPM production practices.

The IPM CRSP continued to strengthen networking activities with the University of Georgia, The National Science and Technology Council in Guatemala, and The National Papaya Growers Association in addressing the ring spot potyvirus in papaya. These networking activities were expanded and strengthened in Year 10 through additional funding.

Research Accomplishments

- Institutionalization of the GOG certified preinspection program for trade expansion in the NTAE sector, including performance protocols, supply source tracking, technology transfers, enforcement policies, and grower training, continued to serve as the "cornerstone" of all IPM CRSP-related research and training activities in Year 10. IPM CRSP developed production strategies and performance protocols to serve as the foundation upon which all preinspection-related GOG programs and policies will be established. In Year 10, preinspection

production and handling training were conducted and the protocols compiled by Luis Calderón in preparation for the production of a preinspection manual. Collectively, these collaborative research activities have helped reduce grower reliance on chemical pest control methods, improved economic returns to growers, and enhanced the socioeconomic welfare of NTAE households.

- The importance of preinspection research accomplishments centers upon the fact that Guatemala's competitive position in the NTAE sector has suffered since 1995 due to sanitary and phytosanitary violations detected at U.S. ports-of-entry. An assessment of U.S. trade data suggests that there is a high correlation between the lack of compliance with the aforementioned non-economic constraints and a decline in Guatemala's competitive position in the U.S. vegetable and fruit market. Further, increased difficulties experienced by importers and exporters as a result of automatic detentions has reduced the number of U.S. importers of Guatemalan snow peas, and has increased the pressure to find alternative snow pea sources. These findings (Dr. J. Julian's thesis) will be used to develop recommendations to enhance the competitiveness of Central American NTAE programs in U.S. markets by the GOG. The IPM CRSP is playing a pivotal role in helping reestablish regional competitiveness and trade expansion in the NTAE sector.

- In collaboration with APHIS-IS and MAGA, assessments were conducted in Year 9 by IPM CRSP researchers to evaluate the potential for papaya in the U.S. marketplace. These assessments found that significant market opportunity does exist, but only for a standardized grade at uniform quality on a consistent basis. These findings further concluded that the greatest market opportunity existed for the Hawaiian (solo) type papaya in the Eastern U.S. markets. This research helped establish the basis for USDA clearance for Guatemalan papaya into the United States, and is serving as the basis for the GOG/APHIS-IS program initiatives developing papaya production in the Petén Region of Guatemala in Year 10 and has been critical in IPM CRSP funded research to develop virus resistant papaya.

- The IPM CRSP research collaboration with Universidad del Valle and the University of Georgia on papaya ringspot problems in Central America has led to the selection of virus resistant genotypes. In the future, this will provide germplasm to allow virus-free papaya production in Guatemala. The research was partially funded by the National Science and Technology Council as a part of a papaya genetic transformation study to incorporate coat protein-mediated resistance into native and Hawaiian-type papayas, and has been an important consideration in the GOG/APHIS-IS decision to target the Petén Region for papaya production. Such development complements the USDA/ APHIS/GOG objectives to establish a medfly-free zone between North and South America. Medfly is a potential threat to North American producers, and is now controlled through intensive chemical control methods.

- In one of the first studies of its kind, IPM CRSP researchers in collaboration with FAO, INCAP and the GOG began evaluating the health affects of IPM adopter households in the NTAE sector of Guatemala in Years 9 and 10. This research activity builds on prior IPM CRSP research that has helped reduce pesticide applications dramatically, and upon current socioeconomic research that finds NTAE households with better health and education benefits. This study further quantified the health status of those households which have adopted IPM/ICM technology in NTAE production, and compares the findings with non-adopter households. This progressive IPM CRSP activity serves as a significant baseline study for future research by Dr. Hamilton to scientifically verify IPM CRSP production technology acceptance on community health and economic levels.

- As previously stated, Year 10 IPM CRSP research achieved substantive validation of the socioeconomic benefits (Drs. Hamilton and Asturias) that accrue from NTAE production and IPM CRSP technology adoption. Findings concluded that adopter households generally witnessed an improved and/or more stable family economic situation and an improved quality of life, with NTAE production and lower pesticide use.

- Socioeconomic surveys found most NTAE producers practice crop rotation, consult with technicians, before fumigation, concerning product choice and application procedures, change pesticides to avoid increasing pest tolerance, and consult concerning registration status of pesticides to avoid the most harmful chemicals. Forty-one percent reported even having monitored pest populations before deciding to fumigate; one-third used insect traps and one-fourth had used biological controls. One-tenth of farmers incorporated multiple IPM technologies, including the use of trap crops and beneficial insects. These farmers reduced the number of chemical applications to an average of seven per growing cycle, as compared with an average of 17 applications for all snow pea farmers. Since only around 40 percent of local NTAE farmers had received alternative pest management extension services, the proportion willing to experiment with alternative practices suggests that farmers are willing to diversify pest management strategies.

- Results were analyzed from a 2002 pilot study of production finance constraints faced by small-scale NTAE producers in Chimaltenango. Rural finance experts in Guatemala City emphasized the high risk of agricultural loan recovery for financial institutions, high interest rates, and a generalized requirement for land as collateral for loans. Among the risks that contribute to higher interest rates are crop losses from pest damage and product detentions for phytosanitary reasons. Formal lending institutions available to small-scale producers in Chimaltenango include the National Rural Development Bank (BANRURAL), intermediary financing institutions/NGOs, cooperatives and agroexporters. Unlike many formal financial institutions, BANRURAL will make loans without requiring land as collateral. The primary source of production financing is not formal lending institutions, but the proceeds of household farm and off-farm production. (Intra-household transfers are common, with women supplying funds for input purchase in nearly half of households surveyed in 2001). Farmers also availed themselves of informal lending by friends and neighbors, but amounts tended to be small. Improving communications between credit suppliers and farmers should alleviate production finance constraints, as farmers do not appear to be collateral-constrained. Institutionalizing IPM adoption should contribute to decreasing lender risk, lower interest rates, and wider coverage for agricultural loans from formal lending institutions.

- These "benefits assessments" were expanded to a larger sample population in Year 10. However, the benefits to our overall program in Central America are already evident. The GOG has proceeded to move more aggressively on matters that assure long-term institutionalization of IPM ICM programs in the NTAE sector. The GOG and APHIS-IS have increased efforts to develop NTAE production in the Petén Region, with particular emphasis on papaya production for U.S. markets. Under the leadership of ICADA, efforts to support the institutionalization of preinspection in the NTAE sector of Guatemala have continued.

- Ph.D research by James Julian used a modified Armington demand model to quantify the impacts of Guatemalan snow pea import detentions on Guatemala's competitiveness with other snow pea supplying regions (California and Mexico) at the U.S. ports of entry. Findings indicate the automatic detention has had a negative effect on Guatemala in the U.S. snow pea market. Import detentions increase the cost of importing Guatemalan snow peas, cause

delays that greatly reduce the marketability of these snow peas and increase market volatility by detaining shipments at U.S. ports of entry for prolonged periods. These findings indicate that the Guatemalan snow pea producers would benefit from the development and implementation of USDA Good Agricultural Practices to address FDA food safety concerns.

- Substantial research has been conducted in IPM strategies in our target crops of snow pea, broccoli, melons, papaya and tomato with the primary objective to develop science-tested IPM programs for improved pest management, reduced pesticide use, more efficiency in pest management and with the final goal of improved markets for NTAE crops. Highlights include:

  1) Master of Science research (Carlos Mayen) studies were conducted over a two year period to investigate the influence of various weed control techniques on the weed soil seed bank in a tomato-soybean rotation. Soil management techniques were conventional tillage, no-till, and winter rye cover crop and weed management involved either a period threshold (weed control for four to six weeks) or a zero threshold (no weeds allowed). Measurements included seeds present in the soil seed bank, weed infestations during the season and crop yield. Data from both years show there was an important influence of crop rotation, weed control intensity and soil management on the soil weed seed bank and weed populations in the growing season. A competitive crop with good canopy closure and well-timed weed control reduce the weed seed returned to the soil regardless of weed control intensity. These results show that long-term effective weed control that prevents large yearly weed seed deposits in the soil seed bank will reduce weed control inputs during the crop production cycle.

  2) The lack of information on the identity, prevalence and distribution of the viral diseases affecting solanaceous and cucurbitaceous crops grown locally prevents their efficient management. Surveys to collect leaf tissue samples with viral-like disease symptoms were conducted during 2003 in four "Departamentos" of Honduras. Incidence and severity of viral infections were recorded at each field sampled. One hundred and seventeen samples collected in the surveys were analyzed using commercial ELISA tests; no testing for Begomovirus was carried out at this time. The analyses showed that mechanically-transmitted and aphid-transmitted viruses are very common in the crops surveyed.

  3) Pods of snow and sweet peas are damaged because of the feeding habits and oviposition of *Thrips* sp., causing the damage known as white spot, green spot or "lija". In order to reduce this damage, farmers apply frequent doses of pesticides. This research was done at FRUTESA in Zaragoza, Chimaltenango. The objective was to determine the efficacy of pesticides to control thrips and reduce pod damage. The variables measured were thrips on snow pea meristems, thrips in flowers, and pods with damage. The best treatments to control thrips in snow pea meristems were: Endosulfan and Polysulfide. Endosulfan, Polysulfide and extracts of plants (Ballisec) reduced the presence of thrips in flowers, and reduced damage in pods.

  4) In order to promote the pre-inspection process of snow pea in Guatemala, this research was conducted by two methods. The first consisted of field training of snow pea producers, in collaboration with Asociación Gremial de Exportadores de Productos no Tradicionales (AGEXPRONT) and exporter companies. The purpose was to improve the quality of snow pea pods. Training was done in four phases: 1) monitoring of plagues, 2) nutrition of the crop, 3) integrated pest management, and 4) use of pesticides. The

second method established demonstration plots of integrated crop management technology in two strategic areas: 1) Aldea El Sitio Patzún, Chimaltenango and 2) Zaragoza, Chimaltenango. The purpose was to promote the use of sound ICM production practices for pest management and crop production. Emphasis was placed on cultivar selection, soil analysis, crop row spacing, soil fumigation, fertilization, monitoring and targeted control of pests, use of faba bean trap crops and "torito" traps to reduce leaf miner infestations, and proper harvest techniques. Growers were instructed on proper record keeping. ICM trained farmers had a 10% snow pea pod rejection percentage while the untrained farmers had a rejection percentage between 40% or 60%. In demonstration plots, eight field days were held at both localities, with participation of 23 technicians, 102 farmers and 33 university students.

5) Embryos have been obtained from local and Hawaiian papaya. These embryos were transformed with the CP gene (coat protein gene for ringspot potyvirus resistance) and differentiated, but trouble with the rooting of the papayas possessing the kanamycin gene has occurred. A variety of methods has been attempted to induce rooting with no success. Riboflavin at a concentration of 10uM and 10uM of IBA are being evaluated to stimulate the production of roots and plantlets are starting to produce roots.

   Fruits of papaya that were pollinated with pollen of transformed male papayas (local and Hawaiian papaya) have been obtained. Seeds from all of the fruits have been obtained and planted. The plants obtained from these seeds are producing small leaves and they will be tested for the presence of the CP gene. Following CP gene presence confirmation, the papayas will be inoculated with the virus (PRSV-p) and tested for levels of resistance.

6) Whitefly-transmitted geminiviruses (genus: *Begomovirus*), potyviruses, (aphid vectored), and tobamoviruses are economic deterrents to solanaceous (tomato, pepper and oriental vegetables) and cucurbits (watermelon, melon, cucumber and oriental vegetables) crops in Honduras, with yield losses estimated at 50-90%. Precise identification of the most important (widespread and damaging) viruses has not been accomplished, yet implementation of rational control strategies that can be integrated in the context of 'a cropping system' approach rely on such information. Presently, farmers rely heavily on pesticides to reduce insect vector populations and thereby abate disease transmission pressures. During a 3-year collaborative effort funded in part by the IPM CRSP, the following begomoviruses were identified for the first time in pepper and/or tomato: the well-characterized viruses *Pepper golden mosaic virus* (PepGMV), *Pepper hausteco yellow vein virus* (PHYVV), and *Havana tomato virus* (HTV), and several partially characterized, but poorly studied viruses: tomato golden mottle-like, tomato severe leaf curl-like, tomato golden mosaic-like, tomato mild mottle-like, and tomato virus (Nicaragua & Jalisco/Baja MEX)-like viruses. In watermelon and melon plantings, variants in the *Squash leaf curl virus* clade were identified for the first time. Also identified in tomato and pepper were *Tobacco etch virus* (TEV) a widespread, aphid borne *Potyvirus,* and the *Tobamovirus, Tomato mosaic virus* (ToMV), which reduces yields up to 80%. ToMV was found with PepGMV and/or other begomoviruses, and synergism was notable, indicating that protection against both begomo- and tobamo-viruses is a priority.

7) In year one of the Biotechnology project (2001) a collaborative effort to develop transgenic tomato plants with resistance to PepGMV and ToMV, and ultimately, to TEV was begun. Honduras is the first Central American country to develop

guidelines for transgenic plant evaluation. The construction of infectious PepGMV clones was completed and characteristic symptoms in tomato and pepper were reproduced. Also, cloning and characterization for two previously unstudied begomoviruses representing two additional begomoviral clades was initiated, and the DNA sequence for the latter four viral components was determined. This will enable their cloning and the construction of infectious viral chromosomes for construction of additional transgenes and to inoculate transgenic plants to test for resistance. The first set of transgenes with inverted repeats for key viral (PepGMV) sequences was constructed along with the corresponding sense and anti-sense controls. Tobacco plants have been successfully transformed and viral sequences are being expressed. T_0 regenerants have been established in soil, and are presently being challenge-inoculated with infectious PepGMV clones. If effective in protecting plants from PepGMV, clones for previously uncharacterized viruses will also be tested when clones are available. Additionally, constructs will be subcloned into the Ti-plasmid carrying resistance to Kanamycin and used to transform tomato. Transgenic tomato will be regenerated and subjected to analysis for transgene integration and expression, and ultimately challenge inoculated by biolistic delivery of infectious PepGMV clones. We expect that this project will lead to the development of transgenic tomato with virus-derived resistance against highly damaging pathogens and to others, if broad-spectrum resistance is feasible. This effort will provide the first technology of its kind to Honduran farmers to combat the most virulent and widespread virus pathogens in tomato crops. In follow-on efforts, resistance can be developed for pepper and cucurbits, which also are hosts for damaging poty- and begomo-viruses in Central America.

Refereed Publications

Brown, J.K. and A.M. Idris. 2003. Infectious clones of *Melon chlorotic leaf curl virus*, a previously undescribed begomovirus in the *Squash leaf curl begomovirus* clade. *Phytopathology* (in press).

Hamilton, Sarah and Edward F. Fischer. 2003. Nontraditional Agricultural Exports in Highland Guatemala: Understandings of Risk and Perceptions of Change. *Latin American Research Review* 38 (3): 82-110.

Hamilton, Sarah et al. n.d. 2003**.** Gender and IPM. In *Globalizing Integrated Pest Management Through Participatory Research*. Chapter is under review.

Presentations and Proceedings

Mayen, Carlos D. and S.C. Weller. 2002. Soil Weed Seedbank Dynamics in a Tomato/Soybean Rotation. NCWSS 57, Abstract 153, CD-ROM Computer File. North Central Weed Sci. Soc., Champaign, IL.

Hamilton, Sarah and Linda Asturias de Barrios. Participatory Models for IPM and Socioeconomic Sustainability in the Guatemalan Nontraditional Export Sector. presented at the American Agricultural Economics Association/Rural Sociology Society Annual Meetings, Montreal, July 27 – 30, 2003.

S. Hamilton served as discussant. AAEA/RSS Joint Session: "International Issues in Integrated Pest Management." American Agricultural Economics Association / Rural Sociology Society Annual Meetings, Montreal, July 27 – 30, 2003.

Hamilton, Sarah. Gender Issues in International IPM, presented at the International IPM panel, Fourth National Integrated Pest Management Symposium, Indianapolis, April 8-12, 2003.

Hamilton, Sarah, Edward F. Fischer, and Linda Asturias de Barrios. Labor Relations in the Nontraditional Agricultural Export Sector in Highland Guatemala. Paper presented at the session "What Does Globalization Mean to

Workers: Working and Organizing in Guatemala." Latin American Studies Association XXIV International Congress, Dallas, Texas, March 27-29, 2003.

Reavis, C and C.R. Edwards. The Application of Integrated Pest Management Strategies to Achieve Sustainable Development and Improvement in Health., presented at the Institute of Agricultural Rural and Environmental Health, Fifth International Symposium, Future of Rural Peoples: Rural Economy, Healthy People, Environment, Rural Communities, Saskatoon, Saskatchewan, Canada, October 19-23, 2002.

Overview of the South America Site in Ecuador

Jeff Alwang, Site Chair (Virginia Tech); Carmen Suárez, Site Coordinator (INIAP);
Victor Barrera, Assistant Site Coordinator (INIAP)

The Collaborative Program

This is the sixth year of activity at the South American site in Ecuador. A total of 12 major activities were conducted during the year. This site operates under a Memorandum of Understanding with INIAP, the research arm of the Ministry of Agriculture in Ecuador. A Site Coordinator and Asistant Site Coordinator manage activities under the CRSP because the crops being researched are primarily found in two locations. Dr. Carmen Suárez serves as overall Site Coordinator and focuses on the work in the lower elevations. She is a researcher at the INIAP Tropical Experimental Station at Pichilingue and coordinates plantain and agroforestry activities. Lic. Victor Barrera serves as Assistant Site Coordinator and focuses on the higher elevations, coordinating activities with potato and Andean fruits. Each activity has a leader who is responsible for interactions with his/her respective coordinators and collaborators.

The work was conducted as a collaborative effort among scientists at INIAP, the International Potato Center (CIP), the Ecuadorian National Potato Program (FORTIPAPA), PROEXANT, the International Food Policy Research Institute (IFPRI), Fundacion Maquipucuna, Eco-Salud, the Soil Management CRSP, the University of Georgia, Ohio State University, Florida A&M University, and Virginia Tech. The CRSP is developing collaborative ties with the local universities and we fund student employees and graduate students. Jointly developed collaborative research plans have allowed us to buy into ongoing research programs and initiate new projects with joint funding.

The Year 10 workplan focused on crops, pests, and constraints identified in the participatory appraisal process. Planning and collaborative research took place through: a) discussions among host country and US/international scientists at planning meetings in Ecuador and Blacksburg, VA, b) joint meetings between IPM CRSP scientists and USAID personnel in Ecuador; and c) preparation of joint host-country/US/international scientist two-page proposals.

Field research is being conducted in farmers' fields in Chimborazo, Carchi, Palora, Tungurahua, El Carmen, and Maquipucuna, with INIAP/CIP scientists visiting experiments on a regular basis. Research is also conducted on site, at Sta. Catalina, the INIAP laboratory in San Gabriel, and Pichilingue.

IPM Constraints Researched

The key constraints addressed in Ecuador in Year 10 were the need to identify and develop IPM solutions to specific pest problems in potato, Andean fruits, and plantain. Additionally, there was demand for information on mechanisms for diffusion of IPM technologies in potato. Specific major pests being addressed in the IPM program are Late Blight (*Phytophthora infestans*), Andean Weevil (*Premnotrypes vorax*), and Central American Tuber Moth (*Tecia solanivora*) in potato; Naranjilla Vascular Wilt (NVW) (caused by *Fusarium oxysporum*) and other pathogens in Andean fruits; and Black Sigatoka (caused by *Micosphaerela fijiensis*), the bacterium *Erwina* sp., and several insect pests in plantain. The work in Maquipucuna focused on identifying and evaluating IPM solutions to pest problems in a mixed coffee and plantain system.

The Ecuador site is thus addressing some of the known production constraints of key horticultural staples in the area. *Phytophthora infestans* is a worldwide limiting factor in potato production. Andean fruits are a source of healthful food for the entire nation, and have potential for export. However, mites, nematodes, fruit and stem borers,

and especially diseases such as *Fusarium* vascular wilt have made it difficult to produce these fruits economically. Vascular wilt in naranjilla has caused the collapse of the native variety in many places in Ecuador; many of these areas are economically and environmentally sensitive.

Research on naranjilla may stabilize production areas in environmentally sensitive areas along the Andean slopes. Increased production of the fruit will enhance economic stability in the northern border region of Ecuador.

Plantain is a staple food for people living in the lowland tropics. Plantain is a substitute for potatoes at lower elevations. The plantain research is especially important, as there has been very little study worldwide of IPM for plantain. An objective of the research in the plantain pest-survey is the identification and quantification of nematodes associated with this crop. This is the first such investigation of its kind of which we are aware.

Selected Research Accomplishments

This year, the Ecuadorian site has had several significant accomplishments:

Alternative means of controlling Central American tuber moth during seed storage and in the fields was developed. Lufeneron, an insecticide which is not toxic to vertebrates, was found to be more effective than *Baculovirus* in reducing damage from the moth's larvae during storage. However, *Baculovirus* together with sun exposure of the seeds was also an effective means of pre-storage control of the pests. *Baculovirus* is more effective in field controls.

The integrated package for controlling Andean weevil in potato has been refined. The recommended package now consists of use of the biocontrol *Beauveria brongniartii* in traps and more limited use of Triflumuron applied to lower leaves of plants. This field-based study builds upon research findings from previous years, and shows significant economic gains to the farmers as well as lower health risks.

Naranjilla grafted onto most accessions of *S. sessiliflorum, S. pseudolulo, S. candidum, S. hirtum, S. hirsutissimun, S. hyporodium, S. robastum* and *S. stramonifolium* appears to have promise for control of NVW. Such knowledge will help considerably in the management of *F. oxysporum* by reducing disease incidence and delaying development of NVW in babaco orchards, chamburo and toronche.

Selection and use of rational insecticides together with strategic application timing appear most promising for controlling naranjilla fruit borer.

The main virus diseases associated with tree tomato production in Ecuador were identified.

The number of fungicide applications for effective control of black sigatoka was reduced to six in plantain using a disease forecasting system, compared to ten applications made using a standard calendar-based program. A strategy for control of black sigatoka in plantain has been identified. Fungicide application techniques have been investigated and a complete IPM package is available.

Agricultural oil showed fungistatic action against black siatoka; however, its effect on the disease was not much different from leaf surgery alone. Black sigatoka is so aggressive under the conditions in Ecuador, that, even in a mild year such as 2003, fungicides should be used to obtain effective control of the disease.

Experiments began to identify pests and means of their control in a plantain/coffee agroforestry system near Maquipucuna. The study is providing information on appropriate IPM strategy for main crops in a very fragile area.

Twenty eight FSs (field schools) were implemented in Ecuador's principal potato-growing regions. The FSs have trained 318 men and 120 women. More than 3,344 potato growers of Carchi and 1,237 from Bolivar, have been involved in different training events. The training activities have been performed at several levels, involving farmers and students, as well as technical personnel from governmental institutions and NGOs. Several workshops have been conducted and the methodology is being extended to other potato-growing areas of Ecuador.

Approximately 1,600 potato growers from Carchi and 450 from Bolivar are currently using IPM practices.

Information on socioeconomic characteristics of plantain-producing families has been compiled and analyzed. Results show strong concern for overuse of pesticides and high potential susceptibility to IPM messages.

Mutuality of Benefits of the Research

The results of the plantain research will have benefits in Ecuador and the region. The U.S. and Europe are becoming major importers of plantain and, as production increases, lower relative prices will encourage and expand global acceptance.

Control of pests in potatoes is a top priority for North America as well as in South America.

The work on Andean fruit is pioneering IPM methods for pest control on these important crops. Naranjilla and tree tomatoes have export potential, but exportability is being limited by diseases. Information from the project will help avoid the introduction of pathogens to other areas of naranjilla production in Ecuador and areas of Central and South America.

The socioeconomic studies will provide information related to pest management and its impacts on household economic and health well being. This information will be of use in evaluating the feasibility and impacts of IPM throughout the Andean region.

Institution Building

Collaborative research and financial support have directly benefited institutions in Ecuador. Several Ecuadorian undergraduate and graduate students are being funded through activities of the CRSP for their Independent Study theses and their MS theses from Ecuadorian universities. This system is helping the CRSP and the universities conduct research and train individuals in applied agricultural research.

Ms. S. Garces is continuing graduate studies in entomology at Ohio State University. She will finish her M.S. in early 2004.

Ms. C. Baez is continuing her graduate studies in Agricultural and Applied Economics at Virginia Tech. She will finish in mid-2004.

Ms. M. Mauceri began graduate studies in Agricultural and Applied Economics at Virginia Tech. She will finish in mid-2004.

Mr. Danilo Vera C. is continuing his M.Sc. studies in Vicosa University, Brazil, financed by PROMSA resources. Collaboration was developed with Profesor L. Maffia, a well known epidemiologist from Vicosa University, and with administrators and scientists from FUNDAGRO.

Mr. Jovanny Suquillo completed his M.S. During Year 10, he completed a sabbatical at CIP-Lima to study techniques for purification of *Baculovirus*.

Patricio Gallegos, Patricia Rodríguez and César Asaquibay trained technicians of the INIAP UVTT–Carchi and the Local Committee of Agricultural Research (LCAR) of Monteverde, and students and teachers of several education centers.

Training workshops were held at Tambohuasha and La Delicia with the participation of 40 farmers (23 women and 17 men). The topics addressed were: biological cycle, behavior, biological control, and integrated management of the Andean potato weevil.

A short-course was held for Palora's farmers regarding training on naranjilla culture and phytosanitary problems; 58 participants (including 18 women) attended this course.

A workshop to elaborate a new project on naranjilla was conducted in the Amazonian city of Macas. Researchers from different institutions participated in this event: Proyecto Agroforestal INIAP-GTZ, Fundación Natura, Programa Sur, Ministerio de Agricultura y Ganadería de Morona Santiago, Estación Experimental Chuquipata of INIAP and ECORAE.

A student from the Faculty of Agronomy of the Central University of Ecuador was trained and carried out research on tree tomato viral diseases. Another student from the same university is carrying out research on virus transmission and epidemiology.

Several field days were held in La Libertad, La Granja La Pradera of Technical University of the North, Eloy Alfaro y Yalquer, in Carchi and Imbabura. 522 persons participated; 35% were women. Field days were also held in Larcaloma and Quinua Corral, in Bolivar, with the participation of 307 persons, and 45% were women. In addition, two observation field trips were organized, related to IPM and FSs, with the participation of 137 potato producers.

An intensive course on IPM and FSs was held, targeting teachers of agro-livestock schools in Carchi.

In January 2003, 28 university students of the Agronomy Schools of the Technical University of the North and of the Catholic University of Ibarra graduated in Field School and Training of Trainers methods. In August 2003 an intensive course for students and teachers of the Catholic University of Ibarra was held.

Luis Escudero, Víctor Barrera, Richard Sandoval and Mario Freire participated as facilitators for the course, Training the Trainers in IPM, for students and teachers of high schools and universities. They trained 1,103 children, 86 housekeepers, 440 farmers/applicators, 39 university teachers, 136 high school students and 74 university students on IPM and pesticides in potato.

Carlos Monar and Angel Rea trained 174 potato producers in three workshops.

The laboratory of the Plant Protection Department in the National Institute of Agricultural Research (INIAP) has been equipped for work on molecular markers. Technicians have been trained to conduct such work. Veronica Galarza attended training at CIP (Santa Catalina, Quito-Ecuador). Her training has been focussed on molecular tools applied to *P. infestans*. Veronica is now trained to carry out future molecular characterization of *P. infestans* isolates. Veronica also attended the course on Environmental Microbiology held at the Catholic University in Quito.

Networking

The IPM CRSP is part of several projects managed by the National Potato Program of INIAP. Work on potatoes is coordinated through the INIAP-PNRT Annual Plan and interacts directly with CIP, the Soil CRSP, Eco-soil, and Fortipapa.

The fruit work is being coordinated through INIAP's department of fruit culture. Other professionals from universities and in research organizations who are working on fruits regularly interact with CRSP researchers. Ongoing research on fruit is being conducted in conjunction with work on INIAP experiment stations.

Studies of biological control were conducted in collaboration with the Catholic University of Ecuador and the Investigation Support Office from France. The collaborating institutions shared information, *Baculovirus* strains, and fieldwork.

Meetings were held for theory and practical training of INIAP technicians and of collaborating farmers. Talks about this technique were delivered to farmers participating in the Field Schools in Carchi, and to the farmers belonging to the Local Agricultural Research Committees in Chimborazo.

Training was also given to students and teachers of several education centers who visited INIAP facilities, including Central University of Ecuador, Polytechnic School of Chimborazo, Polytechnic School of the Army, Technical University of the North and the University of Quevedo.

Fruit research, along with the IPM fruit results, were presented to the following groups of students: the Central University of Ecuador; students specializing in chemistry-biology in high schools such as Hipatia Cárdenas and Inmaculada Concepción of Quito; the Polytechnic School of the Army; the Polytechnic School of Chimborazo; the University of Bolívar; and the Technical University of Ambato.

Plantain research results have been shared with INIBAP (the international banana research center) forum and INIBAP personnel. The student in charge of this research was invited to participate in a course in the Dominican Republic to demonstrate and discuss the progress of the research.

In the plantain area, links between researchers and AATP´s (Private Extension Agents) have been established. These links will facilitate further work in the area.

Plantain activities have been coordinated with INIBAP. The plantain work has also involved local agricultural high schools and universities. Plantain work includes interactions with IGN (the military geographic institute), CLIRSEN (the Ecuadorian remote sensing institute), the Ecuadorian foundation for ecological studies, and others.

Activities in Maquipucuna are being conducted jointly with the University of Georgia, Fundacion Maquipucuna, and the "Choco-Andino Corridor" project, a large multi-institutional integrated project. Workshops have been held in the Biology Department of the National Polytechnic School.

Overview of the South Asia Site in Bangladesh

Edwin G Rajotte, Site Chair (Penn State); ANM Rezaul Karim, Site Coordinator,
(Horticulture Research Center, BARI)

The Collaborative Program

IPM activities at the Bangladesh site were concentrated in four program areas during Year 10, which was Year 5 for Bangladesh. The first of these areas was vegetable crop pest survey and monitoring; the second was multidisciplinary pest management experiments; the third was laboratory, greenhouse and microplot experiments for biological control; and the fourth was socioeconomic analyses. The work was conducted as a collaborative effort among scientists at the Bangladesh Agricultural Research Institute (BARI), the Bangladesh Rice Research Institute (BRRI), Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), the Asian Vegetable Research and Development Center (AVRDC), the International Rice Research Institute (IRRI), the University of the Philippines- Los Banos, Penn State University, Ohio State University, Purdue University, and Virginia Tech. ANM Rezaul Karim served as Site Coordinator and Edwin G. Rajotte as Site Chair.

The Year 10 workplan focused on crops, pests, and constraints identified in the participatory appraisal process and in the previous year's crop pest monitoring. Pest management experiments and socioeconomic analyses were refined using the knowledge gained in the past four years. Planning and collaborative research work took place through: a) discussions among host country and US/international scientists at planning meetings in Bangladesh and b) preparation of joint host–country/US/international scientist two-page proposals. Planning for Year 11 also involved discussion of the plans jointly with scientists working in the Philippine site during the annual planning workshop at Westin Inn, Indianapolis in April 2003.

Field research is conducted in farmers' fields in Kashimpur and Sripur of Gazipur district, and in Jessore, Comilla, Chittagong and Rangpur districts, with BARI/BRRI scientists visiting experiments at regular intervals. Some research is also conducted on-station, especially varietal screening for insect, disease, and nematode resistance in eggplant, tomato, okra and pumpkin. Training takes place primarily at U.S. universities, UPLB (Philippines) and BSMRAU (Bangladesh). CARE-Bangladesh participated in the planning and field visits and teamed up with IPM CRSP to disseminate IPM CRSP technologies in intensive vegetable growing areas through their existing extension programs. Technical Officers of CARE-Bangladesh received practical and theoretical training from IPM CRSP on the technologies.

Pest management research encompassed three major thrusts. The first thrust was a continuation of crop pest monitoring for the fifth and final year. The second thrust included various manipulations of the host plant to provide insect and disease resistance (varietal screening, rootstock grafting, hybrid production). The third thrust involved investigations of the effectiveness of various IPM tactics against key pests in various vegetable crops (IPM approach for cabbage pest control, virus infection timing, fruit fly bait trapping, soil amendments against soil-borne disease, integrated management for weeds and diseases, and biological control).

Socioeconomic studies included a continuation of the analysis to measure economic impacts of Bangladesh IPM CRSP research activities, adoption of IPM practices in different regions of Bangladesh and integration and diffusion of IPM technology.

IPM Constraints Addressed

The key constraints addressed in Bangladesh in Year 10 were the need for IPM solutions to specific pest problems in vegetables and the need for information on socioeconomic factors influencing

adoption of IPM. Specific major pests being addressed in the IPM program included eggplant fruit and shoot borer (*Leucinodes orbonalis*), bacterial wilt (*Pseudomonus solanacearum*) in eggplant and tomato, fruit fly in cucurbit crops, diamond back moth and other leaf-eating insects in cabbage, soil-borne pathogens (*Fusarium* and others) and root-knot nematode in eggplant, tomato, okra and gourds, virus diseases in okra and sweet gourd, and various weeds in tomato and okra.

Selected Examples of Research Progress and Results

Detailed descriptions of research progress and results are provided in the individual institution activity reports. The following is a brief summary.

Replicated trials carried out at BARI farm, Gazipur and at the Regional Agricultural Research Station in Hathazari of Chittagong district showed that three sucking insects (whitefly, aphids and jassids) were prevalent on eggplant, tomato and country bean. Populations of whitefly, which have been increasing for the last few years, were high on most of the crops. These insects were also responsible for transmitting different virus diseases, particularly to tomato and country bean crops.

Surveys conducted at Gazipur and Jessore showed that the bean pod borer infestations were 2-3 times higher in farmer fields that received weekly or daily pesticide applications. This practice seriously hindered the natural control systems, and affected their populations, particularly that of the parasitoids, which were recovered only from pod borers collected from unsprayed fields. Indiscriminate pesticide use is probably responsible also for the increased populations of other pests like whitefly and aphids that presumably transmitted virus diseases. A biological control program is expected to be a suitable strategy for pest control in country bean crops.

Evaluation of the selected eggplant varieties produced very promising results. Five eggplant lines showed resistant reactions to bacterial wilt disease, and eleven to root-knot nematode. Eleven eggplant varieties/lines exhibited high to moderate resistance to fruit and shoot borer (FSB) consistently for three years. Antibiosis and antixenosis tests strongly indicated that these varieties are genetically resistant to FSB. The selected FSB-resistant varieties include two cultivated varieties, Kazla and Uttara, which if cultivated widely can minimize FSB infestation effectively and will ultimately reduce pesticide use at the field level. Several of these varieties also have various degrees of resistance to jassids, bacterial wilt and root-knot nematode. In 2003-2004, the eggplant lines ISD-006, BL-009 and BL-114, which also have good horticultural qualities, will be demonstrated to farmers in an IPM package for production of healthy and profitable eggplant crops. Similarly, several tomato varieties/lines have been selected with resistance to BW and RKN, which will help develop pest-resistant tomato varieties.

Grafting of eggplants and tomatoes was highly successful in respect to its compatibility, grafting success, BW disease control, yields and economic returns. In pilot production of grafted eggplants in farmer fields in Jessore and Sripur (Gazipur), only 1-5% of the grafted eggplants died from diseases as compared to 17-26% in the fields of farmer practice. Harvest period of the grafted plants was about one month longer, producing about 1.5 times more fruits per plant and two-fold higher yields than the non-grafted ones. As a result, farmers gained 2.5 times more income from growing grafted eggplants. Similarly, grafting of tomato on eggplant rootstock was highly compatible with an average of 94% grafting success. Average mortality of tomato grafts from BW disease was below 1% as opposed to 19% of the non-grafted ones. On the average, grafted tomato plants had 120% more fruits and produced over 1.6 times more yield bringing about 1.5 times increased income.

Heterotic performances of 36 hybrids of eggplant (*Solanum melongena* L.) involving nine parents showed that eight hybrids (BL-081 x BL-113; BL-081 x Uttara; BL-083 x BL-113; BL-083 x BL-114; BL-009 x Islampuri; Kazla x Bl-113; Kazla x Bl-114; and Bl-099 x Islampuri) were promising. They were early for harvest, had better fruit size, shape and color, and produced more fruits and higher yield per plant than the remaining hybrids. They also showed a higher percent of heterosis for the above characters over their mid-parents and better

parents. These hybrids may be nominated for farm level use after confirmatory tests.

Evaluation of 40 selected pumpkin lines in the field for their reaction to different virus diseases and tests of virus infected samples through ELISA showed that PRSV, along with unidentified viruses of the poty virus group is the major virus disease of pumpkin in Bangladesh. Six plants of five pumpkin lines were selected for advanced trials based on their satisfactory virus resistance and acceptable horticultural qualities. The selected materials have potential to be used in the field as improved varieties.

Field screening of local okra germplasm was highly successful. High *Yellow Vein Mosaic Virus (YVMV)* infection intensity in the field helped to discern the resistant and susceptible materials. Out of 38 test entries, two were highly resistant with no virus infection, four were resistant with 5-25% infection, and another four were moderately resistant with 33-50% infection. Further tests of these selected materials may lead to identification of virus-resistant varieties that can be used by the farmers.

Thirteen on-farm demonstration trials conducted in Comilla and Jessore districts clearly demonstrated the advantages of IPM practices for cabbage pest control. The IPM practice consisting of handpicking controlled 70-100% of the leaf-eating caterpillars of *Spodoptera* sp. and diamond-back moth, increased the yields by 11% to 21% and fetched 19% to 33% higher net income. No pesticide was used in the IPM practice. Farmers, on the other hand, applied insecticides 6-13 times without much success, as the insecticides could not reach the targets of pest infestation. The IPM approach clearly demonstrated that healthy, pesticide-free cabbage crops can be grown in large scale.

Exclusion of the vector insects (whitefly, aphids and jassids) by the use of 2m high net barriers around the okra plots effectively reduced virus infection resulting in better crop growth and much higher yield. Since the erection of a net barrier at the farm level is difficult and less practical, a cost-effective and more suitable measure is needed. In the present study, insecticide protection with malathion was not effective.

In Bangladesh, okra is cultivated in the summer season, and cabbage and tomato in the winter season. On-station trials to grow these crops in the off-season (okra in the winter and cabbage and tomato in the summer) by protecting them from biotic (insects and diseases) and abiotic (temperature and rains) stresses showed a possibility of growing them in small plots or home gardens, but the cultivation was not cost effective. The crops were grown under ‘polytunnels’; one set having a polythene top and a net barrier along the sides, the other with only a polythene top. Plots without any protection served as the control. Okra grown under both kinds of tunnels during November- April (winter season) had better plant establishment and growth, and produced 2-4 times higher yield. In the off-season cabbage production trials during June-October (summer and rainy), plants grown without protective structures suffered high damage from leaf-eating caterpillars and rotting diseases, and no plants survived. Under protective structures, 63% of the plants survived, but produced small cabbage heads, each weighing about half a kilogram.

The cucurbit fruit fly showed highest preference for bitter gourd, followed by sweet gourd, ash gourd and cucumber. Infestations started from the time of fruit initiation and continued as long as the crops produced fruits, suggesting continual control measures starting from fruit initiation. Mass trapping with MSG and cuelure pheromone baits was highly effective for the control of fruit fly and higher production of cucurbit crops free of pesticides. The mass trapping technique reduced fruit fly infestations by 53–73% and produced 1.4 to 2.3 times higher yields when compared with the farmer practice of weekly or fortnightly pesticide applications. The farmers were highly impressed and showed keen interest to adopt the technology in large scale in their cucurbit crops.

The FSB-resistant eggplant lines BL-114, BL-009 and ISD-009 showed high degree of resistance to FSB, jassids and bacterial wilt disease. These resistant eggplant lines controlled FSB infestations by 68% at the vegetative stage and 58% at the fruiting stage, jassids by 50-60%, and bacterial wilt disease by 66% when compared with that of the susceptible eggplant variety Chega. Grafting of resistant or susceptible eggplant variety on BW-

resistant rootstock was highly effective to control bacterial wilt disease providing 90-95% control of bacterial wilt disease. Sanitation consisting of removal of FSB infested twigs of eggplant also contributed significantly to control FSB. Integrating resistant varieties, grafting and sanitation, an IPM package, can be developed for effective control of FSB.

Organic soil amendments often tend to induce weed proliferation in vegetable crop fields. On-farm trials on integrated management of weeds and soil-borne diseases through soil amendment treatments by using poultry refuse and mustard oil-cake in tomato fields, however, showed no significant proliferation of weeds. On the other hand, soil amendment treatments reduced plant mortalities and gave good establishment of the crop. Like other weed management trials, tomato plots receiving two hand- weedings at 20 and 40 days after planting effectively controlled the weeds and produced higher or similar yields as that of the farmer practice receiving four-hand weedings. On average, two-hand weedings saved about 50% weeding cost and fetched better economic returns.

Organic soil amendment treatments, such as incorporation of poultry refuse, mustard-oil cake, and burning of sawdust were highly effective in controlling soil-borne pathogens in tomato and eggplant crops in seedbeds and in the main planting fields. These practices reduced disease-induced plant mortalities, enhanced plant growth and yields and brought about more economic returns to farmers. Among the treatments, the uses of poultry refuse and mustard oil-cake showed better results as observed in previous years in other crops. Farmers have already adopted the practice in several areas.

Easy and efficient methods have been developed for multiplication of eggplant FSB and its egg parasitoid in large numbers. In laboratory tests, the parasitoid caused as much as 76% parasitism of FSB eggs. Since the parasitoid is widely available in eggplant fields, its augmentation and conservation by avoiding pesticide use in eggplant crops can effectively contribute to sustainable control of FSB.

On-farm demonstrations conducted from 2001 to 2003 with full participation of the farmers on soil amendment practices for the management of soil-borne diseases in cabbage and eggplant, fruit fly control by bait trapping in cucurbit crops, and eggplant grafting on wild *Solanum* rootstocks were highly successful in respect to effective pest management, increased yields and higher economic returns. On an average, the farmers received 33% increased yields in cabbage and 49% in eggplant, and gained 1.5 times higher economic returns by using the organic soil amendment practices. Bait trapping for cucurbit fruit fly control created extraordinary impact for the farmers who named it “magic trap”. Hundreds of fruit flies were caught in the traps daily resulting in 58-76% lower fruit infestation and damage, as compared to farmer practice, and producing 50-60% higher yields and fetching 51-59% more economic benefits in sweet gourd crops. Similarly, the eggplant grafting technique was highly effective for producing healthy eggplant crops with 2.5 times higher yields that fetched about 3 times more economic benefits to the farmers. The results of the demonstrations created a strong impact on the participating farmers as well as the neighboring ones. They learned improved methods of vegetable cultivation, particularly the benefits of IPM practices without interventions of pesticide use.

Mutuality of Benefits of the Research

The pest problems assessed in these studies are common and widespread in Asia and also in other parts of the world. IPM approaches to manage these problems have broad applicability, especially in Asia. The cultivation and consumption of vegetables are growing in Bangladesh and the region. The primary feedback in terms of benefits to the United States will be through (a) the effects of economic growth in the region on trade and demand for U.S. products in international markets and (b) improved relations in a politically sensitive area of the world.

Institution Building

Equipment, vehicles, and other support

Funds were provided for vehicle repair, maintenance, and rental to facilitate transport to and from research sites. Expenses for greenhouse and

laboratory renovations, purchase of computers, a copier and various supplies were provided.

Research training

One Bangladeshi student, Nazrul Islam, is continuing his Ph.D. degree program in weed science at UPLB in the Philippines. One Bangladeshi student, F. Zaman, is continuing his M.S. degree program at Penn State in Entomology. One Bangladeshi student, Ms Nahar, is undergoing extensive training at Ohio State in support of her Ph.D. degree at the BSMR Agricultural University in Bangladesh. One Bangladeshi scientist, Syed Nurul Alam, participated in the Fourth National IPM Symposium in Indianapolis, USA and presented three posters on vegetable IPM technologies. Two Bangladeshi scientists, M. Nasiruddin and Shawquat Ali Khan, completed a three-week study tour-cum-training on vegetable IPM and weed science at PhilRice/UPLB in the Philippines. Three Bangladeshi scientists, M. Al-Amin, Shahabuddin Ahmad and Syed Nurul Alam, completed a month-long training on eggplant biotechnology at Tamil Nadu Agricultural University, India. Two Bangladeshi scientists, Selim Reza Mollik (M.S. in horticulture) and Khorsheduzzaman (Ph.D. in entomology) are pursuing their degree studies at the BSMR Agricultural University in Bangladesh. IPM CRSP is also providing financial support for three Bangladeshi M.S. students, Abu Jafar Alponi (BAU), Rayhanul Islam and Mahmuda Akter (BSMRAU), for their M.S. theses research on vegetable IPM socio-economic studies.

Scientist travel

S. K. De Datta and Robert C. Hedlund travelled to Bangladesh in December 2002 to review research progress and hold meetings with USAID, BARC, BARI, BRRI and ATDP. G. Norton, E. Rajotte, G. Luther, S. Miller, and R. Gilbertson travelled to Bangladesh in January 2003 to review research results and help plan additional research. They also attended a farmer field day at the Jessore site. R. Karim along with G. Norton, E. Rajotte and S. Miller visited Tamil Nadu Agricultural University in India to discuss and work out the plans for developing biotechnology programs on eggplant fruit and shoot borer in Bangladesh. R. Karim and Syed Nurul Alam travelled to Indianapolis to participate in the Fourth US National IPM Symposium and to attend the IPM CRSP annual workshop and planning meeting and to discuss administrative issues.

Human resource development

A human resource development plan for the next two years was revised that includes both short-term and degree training.

Networking Activities

Networking is accomplished through institutional collaboration among BARI, BRRI, UPLB, BSMR Agricultural University in Bangladesh (BSMRAU), CARE-Bangladesh, and IRRI-Bangladesh. IRRI and AVRDC play key roles in networking with other countries in the region. Scientists involved in the project work throughout the region and spread research results through visits to other countries and participation in workshops, meetings, and other networking activities. U.S. universities also help with networking in the region. Some of the scientists on the project also work with the Philippines site, and the weed scientist from UPLB works at the Bangladesh site. The site coordinator has networked with many other host country and foreign supported projects in the country, both hosting them at the IPM CRSP site, and attending meetings in which multiple organizations are represented.

Research Accomplishments

Research progress and key results for the past year are summarized above. Particularly significant among those listed are the success with the eggplant and tomato grafting program for bacterial wilt, soil amendment practices to control soil-borne diseases in vegetables, IPM practice for cabbage pest control, and the use of bait traps to reduce fruit fly in gourds, as were the results of biological control of eggplant fruit and shoot borer, and cost effective weed management practice in vegetable crops. In addition, during the visit of the overseas scientists to Jessore, the results of the IPM CRSP research were highlighted during a day-long ‘farmer field day’, attended by the Minister of Agriculture and about 1500 farmers and members of the local

‘agricultural clubs’, including local extension agents of government and non-government extension organizations and school teachers. Also, a one-day farmer training on various vegetable IPM practices, including practical training on eggplant graft preparation, was conducted at Jessore. Twenty-five farmers, including three women and three nurserymen, participated in the training program. IPM CRSP/BARI teamed up with CARE-Bangladesh and trained 22 Technical Officers for dissemination of IPM CRSP technologies at the farm level.

Overview of the Southeast Asia Site in the Philippines

Sally Miller, Site Chair (Ohio State University); Aurora M. Baltazar, Site Coordinator (PhilRice); and Herminia R. Rapusas, Interim Site Coordinator (PhilRice)

The Collaborative Program

IPM activities in the Philippines site were concentrated in four program areas during Year 10:

- multi-disciplinary, on-farm pest management experiments;
- multi-disciplinary laboratory, greenhouse, and microplot experiments;
- IPM technology transfer and feedback; and
- socioeconomic analysis and training.

The work was done as a collaborative effort among scientists at the Philippine Rice Research Institute (PhilRice), the University of the Philippines-Los Baños, Leyte State University, Central Luzon State University, the International Rice Research Institute (IRRI), the Asian Vegetable Research and Development Center (AVRDC), Ohio State University, Penn State University and Virginia Tech. The IPM CRSP Philippines team also collaborated with the IPM CRSP South Asian site in Bangladesh and Tamil Nadu Agricultural University (India).

The Philippines site of IPM CRSP was successful in Year 7 in obtaining approval for P.L. 480 funds. The 5-year, $1.3 million (USD) grant entitled "Enhancing the Implementation of IPM to Improve Farmer Competitiveness, Minimize Environmental Risks and Insure Food Security and Safety", was scheduled to begin in January, 2001. However, due to fiscal problems in the Philippines government, the allocation of funds has been delayed repeatedly, and the current estimate is that funds may be released in January, 2004. The total funding level may also be decreased, in which case the following original objectives will be modified accordingly: 1) Explore and implement IPM technologies and generate new technologies for high-value vegetable crops for reduced pesticide misuse, increased farm product marketability, and farm profitability; 2) Develop transgenic crops for improved vegetable production; 3) Assess economic aspects of improved IPM technologies in rice-vegetable production among small farm units; and 4) Develop training materials and implement season-long vegetable collaborative IPM programs. Expansion of IPM CRSP activities into additional provinces with rice-vegetable cropping systems is an integral component of Objective 1. Initial expansion activities and development of training materials and programs (Objective 4), have already been started.

The Year 10 workplan was focused on crops, pests and constraints identified in the participatory appraisal process, a structured baseline survey and crop monitoring in years two through four. Planning and collaborative research efforts for the year took place through:

- discussions among U.S., Philippine and other cooperating scientists at planning meetings in the Philippines;
- joint host-country/U.S. scientist two-page proposals;
- a workshop among cooperating scientists to integrate the two page proposals into the overall plan and budget;
- revisions to the plan followed by review by the scientists, ME and USAID.

Field research is conducted in six villages in San Jose, Nueva Ecija, in Bongabon, Nueva Ecija, and at the PhilRice experimental farm, also in Nueva Ecija. The host country site coordinator oversees the field research activities. U.S., UPLB, LSU, CLSU, IRRI and AVRDC scientists visit the sites periodically to address specific projects. Laboratory and field research is also conducted at AVRDC in Taiwan, and training activities take place at Virginia Tech, Ohio State, Penn State, UPLB and AVRDC.

As a part of the IPM CRSP expansion into additional rice-vegetable cropping areas in the Philippines, a participatory appraisal process was completed in the provinces of Ilocos Norte, Nueva Viscaya and Pangasinan. The appraisals were carried out by Philippines IPM CRSP scientists and collaborating researchers attached to PhilRice and local universities.

IPM Constraints Studied

Key constraints to IPM in the Philippines that were addressed during Year 9 were:

- absence of economical IPM solutions for specific pest problems;
- lack of basic understanding of the biology of specific pests;
- lack of knowledge of sources of germplasm for resistance to insects, pathogens and nematodes;
- absence of knowledge about policies, sociocultural beliefs and perceptions, regulations and other factors influencing pest management practices.

Specific major pests being addressed in the IPM program are the root knot nematode (*Meloidogyne graminicola*), bulb rot (*Fusarium* spp.), pink root (*Phoma terrestris*), anthracnose (*Colletotrichum* sp.), cutworms and armyworm (*Spodoptera* spp.) and various weeds, particularly *Cyperus rotundus* and *Trianthema portulacastrum* in onions. In eggplant, fruit and shoot borers (*Leucinodes orbinalis*), leafhoppers (*Amrasca biguttula*) and bacterial wilt (*Ralstonia solanacearum*) were studied. Research on pathogens causing anthracnose (*Colletotrichum* spp.) and bacterial leaf spot (*Xanthomonas campestris* pv. *vesicatoria*) of pepper was also conducted.

Selected Accomplishments

Descriptions of research progress and results are provided in the individual institution/activity reports. The following are examples of progress and key results obtained at the Philippines site.

• Chemical or mechanical stale-seedbed treatment (SST) applied once or twice in a 1-year rice-onion rotation cycle, combined with the farmers' practice of burning rice hulls, reduced purple nutsedge tuber and shoot densities by 80 to 90% of initial populations at the end of the fifth crop, decreased handweeding times and weed control costs by 50 to 60%, and increased yields over those of untreated plants. Net incomes from stale-seedbed treatments were higher by 20 to 30% over those of farmer's practice plots. Data from 2-year results indicate that SST is a multi-season long-term approach that is more effective than a single season or a single crop approach.

• Postplant application of the herbicide glyphosate with a shielded nozzle, a shielded sprayer or a paintbrush at 2 to 3 weeks after onion plant emergence controlled purple nutsedge and other weeds with adequate selectivity to the crop, reduced weed growth and yielded higher than plots treated with farmer's practice, glyphosate applied preplant, or unsprayed plots. Among the postplant methods, the shielded nozzle took the least time to apply, had less weeds and thus had higher yields and net incomes than the shielded sprayer or paintbrush. However, it did not yield as high as the stale seedbed treatments or those that were handweeded three times, indicating that glyphosate applied postplant, even with directed applications, may have caused some degree of injury to the onion plants.

• More larvae of the onion leafminer *Lyriomyza trifolii* collected in Nueva Vizcaya (15 – 41%) were parasitized than in Nueva Ecija (10.5 - 18.6%). This could be attributed to the lower frequency of insecticide application in Nueva Vizcaya than in Nueva Ecija. Yellow sticky board traps caught significantly more adult flies than boards of three other colors. The combination of natural biological control agents like larval parasitoids and use of yellow sticky board traps against *L. trifolii* could be an important component for the management of this insect in onion and other vegetables.

• In a dry season survey of eggplant production fields, the incidence of bacterial wilt ranged from 0-80% in Pangasinan, 5-50% in Nueva Ecija and 0-25% in Batangas. Initial results of a wet season survey in Quezon and Batangas showed 10-30% and 36% bacterial wilt, respectively. Of 197 Pangasinan isolates of *Ralstonia solanacearum* collected, 6.1% belonged to biovar 3 and 93.9% were biovar 4. For the Batangas isolates, 38.7 %

were biovar 3 and 61.3% were biovar 4, while 80% were biovar 3 and 20% were of biovar 4 among the Nueva Ecija isolates.

• Six eggplant cultivars were screened for resistance to Philippine strains of *Ralstonia solanacearum* in the greenhouse. Three entries were resistant and two were moderately resistant. The wild eggplant, *Solanum sisymbrifolium*, which is resistant to Bangladesh strains of the pathogen, was susceptible to bacterial wilt in the Philippines. Grafting different rootstock and scion combinations effectively reduced bacterial wilt infection. None of the 15 bacterial wilt-resistant *Solanum* spp. that are candidates for use as eggplant rootstock was rated resistant to *M. incognita* and *M. graminicola.*

• Seventeen crosses were produced and screened for combined resistance to leafhopper and eggplant borer. F1's of the seven crosses showed promising response to the leafhopper under field and greenhouse conditions. Leafhopper counts were highest in commercial hybrids 'Casino' and 'Jackpot' and lowest in the native varieties 'Parat', 'Abar' and 'A300'. In the protected field, the insecticide 'Actara' was effective in controlling leafhoppers. The yield in the protected plots was highest on 'M16' and 'Jackpot 'while the highest yielder under the unprotected plots was 'M16' followed by 'Casino'. Waterlogged conditions during the two typhoons greatly affected yield. 'A300' and 'M16' showed resistance to waterlogged conditions.

• Weekly removal of eggplant fruits and shoots damaged by the eggplant fruit and shoot borer resulted in the highest yield of healthy fruits and lowest incidence of damaged fruits among several treatments, including weekly spraying of insecticides (chlorpyrifos+BPMC). Farmers' indigenous pest control practices such as dusting with burned rice hulls resulted in a high incidence of damaged fruits. Unsprayed control plots had yields comparable to those of weekly-sprayed plots.

• Wider spacing (18 x 20 cm) of onion seedlings with low nitrogen (60kg/ha) application and Mancozeb application at seven-day intervals significantly reduced the incidence and severity of anthracnose of onion. However, the yield did not differ significantly from that of other treatments, except for those with standard spacing, low nitrogen and fungicide.

• The mean frequency of insecticide applications was reduced from 4.4 in farmer practice onion plots to 2.6 in plots managed using IPM CRSP - developed technology (applying insecticides based on catches of male *S. litura* and *S. exigua* moths in sex pheromone baited traps). Percent damaged leaves taken four times during the crop ranged from 3.7-4.7% and 3.6-6.3% in researchers' and farmers' plots, respectively. There was no significant difference in the mean yield between farmers' plots and the researchers' plots. Although farmers applied more insecticides than the researchers, the level of insect damage and yield was not affected.

• Removal of all onion leaves at 15 days after transplanting (DAT) resulted in a significant reduction in onion bulb size and weight. Similar results were recorded when the youngest leaf was removed at 60 DAT. Removal of 1-3 oldest leaves at 30 and 45 DAT and youngest leaf at 15, 30, and 45 DAT resulted in slightly larger and heavier bulbs compared to the control. However, removal of only the oldest leaf at 15, 30, 45, and 60 DAT generally resulted in bigger and heavier bulbs compared with the other treatments. It is evident that removal of different numbers of leaves at different times was not detrimental to the yield of the onion plant except at the critical stage of bulb formation. This indicates that onion plants can compensate for early season damage caused by defoliators.

• Colonization on onion roots by applied mycorrhizae (VAM) was higher in 'Yellow Granex' than in 'Red Creole'. VAM did not prevent root-knot and pink root incidence. Combination of VAM and chicken manure at transplanting resulted in 15% to 22% yield advantage over the control compared with VAM and cow manure. There were no differences among VAM, Vital N®, and Bion®, giving VAM an advantage in terms of cost-effectiveness. In a microplot experiment, VAM plus composted rice straw increased plant height and fresh weight and

reduced the number of root galls. VAM plus composted sawdust similarly reduced the number of galls. VAM combined with organic materials, however, did not significantly reduce the nematode population in onion roots or soil.

• Two of four formulations of the commercial biocontrol agent 'Nemaguard' were effective against *M. graminicola* when applied a week before nematode inoculation.

• The biocontrol agents *Trichoderma viride* and *Trichoderma* sp. (T5-onion isolate) reduced the incidence of onion bulb rot caused by the soil-borne pathogens *Sclerotium cepivorum* and *Fusarium oxysporum* f.sp. *cepae.* The two antagonists also reduced root infection caused by *Phoma terrestris*, but not as effectively as fungicide.

• The yield of 'Yellow Granex' without N application (control) was significantly higher (22.2 ton/ha) than yields from 50 N, 100 N and 200 N treatments. Highest yield in 'Red Creole' was recorded in the treatment with 50 N (17.22 ton/ha). 'Yellow Granex' stored at 27^{o}C room temperature lasted four weeks while in 'Red Creole', 100% rotting was observed only after 12 weeks in storage. Cold storage of both types of onions resulted in significantly longer bulb viability (at least 12 weeks) than storage at room temperature. *Aspergillus flavus, A niger, Burkholderia cepacia* and *Fusarium* sp. were the causal organisms of bulb rot under storage. *A. flavus* was the predominant bulb rot microorganism in 'Red Creole' and *A. niger* in 'Yellow Granex' at room temperature while *Fusarium* sp. was prevalent in 'Yellow Granex' at 0^{0} C.

• Twenty *Spoladea recurvalis* larvae consumed 36% and 81% of leaves of *Trianthema portulacastrum* (horse purselane) plants within 24 hours and 14 days after release, respectively. The number of flowers and capsules produced by the plants was significantly reduced when infested with 20 larvae. *S. recurvalis* preferred younger plants (15-30 days old) than mature (60 days old) *T. portulacastrum* plants. Of 13 other crop and five weed species tested, the insect fed and completed its life cycle only on *Amaranthus viridis* and *Portulaca oleracea.*

• Using Krawetz' Social Impact Assessment (SIA) Model, researchers evaluated farmers' perception of sex pheromone traps as a monitoring device to determine the time of insecticide application for *Spodoptera litura* and *Spodoptera exigua* on onions. Farmers were enthusiastic to try the technology in their own fields. They also perceived that it seems to have no adverse effect on their health and the environment. With proper training and an information campaign, the use of sex pheromone traps as a monitoring device can significantly reduce the input cost of insecticides. However, the use of sex pheromone traps as perceived by some farmers will not reduce their insecticide application if problems due to other pests are not addressed. Farmers believe that other insects are still present in their fields so they still need to apply insecticides for "preventive" measures assuming that these other insects will cause a significant reduction in their yields. They also want the technology to be accessible and adopted at a community-wide level.

• All strategies for pre-storage curing of bulb onions provided additional income from storage of the onions. Sun-drying and no curing provided the highest yield recovery rates from post-harvest storage of 'Red Creole' onions. Additional income of up to P9.38/kg in 2000-2001 DS and P5.55/kg in 2001-2002 DS was realized from storage of onions. All proposed pre-storage curing techniques were economically acceptable both on the consumer and producer sides. Economic surplus went mostly to the consumers. All alternatives also provided positive net present values (NPVs) and high internal rates of return (IRRs). No curing and sun-drying before storage, however provided the highest NPVs and IRRs. The adoption of these techniques will increase the supply and reduce selling price of onions year-round.

Mutuality of Benefits of the Research

Most of the pest problems addressed in the Philippines site activities are widespread throughout Asia and also occur in other parts of the world.

Strategies developed to manage these pests economically and sustainably can thus be applied to other countries. IPM methods developed for managing pests of onion and eggplant are particular examples. We continue to cooperate with IPM CRSP Bangladesh and AVRDC, through the GTZ-funded Periurban Project, in development of eggplant grafting technologies to manage bacterial wilt disease. Economic and social impact analyses have shown that strategies such as the use of pheromone traps to time application of insecticides are socially acceptable and economically beneficial to farmers in Central Luzon. These strategies are likely to benefit farmers in other Asian countries as well in the near term, and have the potential to be adopted in other regions.

Institution Building

Funds were provided for long-term rental of a vehicle for travel to and from research sites. U.S. scientists also provided research supplies during visits to the Philippines site. Research articles were sent from U.S. cooperators, and bibliographies were prepared at Penn State and provided to IPM CRSP scientists. Approximately 50% of the total Philippines site budget was allocated to PhilRice and cooperating institutions in the Philippines. Technology transfer and IPM CRSP expansion studies were primarily funded by PhilRice as part of its current mission to include vegetable IPM as a component of rice production systems.

Human Resource Development

Edwin Martin received an M.S. degree in weed science from UPLB during Year 10. Irene Tanzo is pursuing a Ph.D. degree in rural sociology at Penn State.

Networking Activities

Networking is accomplished through institutional collaboration between PhilRice, UPLB, LSU, CLSU and other agricultural colleges in the Philippines. PhilRice is part of the Department of Agriculture (DA) and its national IPM program coordinates with IPM CRSP.

S.K. De Datta traveled to the Philippines on March 17-21, 2003 and was plenary speaker on globalization of IPM at the 19th conference of the Asian-Pacific Weed Science Society held in Manila. He also met the Secretary of the Department of Agriculture, the PhilRice Director, and officials of USAID and USDA regarding IPM CRSP matters.

A.M. Baltazar, M.C. Casimero, J. M. Ramos, and E.C. Martin attended the 34th conference of Pest Management Society of the Philippines and presented papers on IPM CRSP research results at the scientific sessions of the Weed Science Society of the Philippines held May 6-9, 2003 in Cebu City, Philippines.

N. Opina and M. Caasi-Lit visited the IPM CRSP South Asia site in Bangladesh (BARI, Gazipur), March 9-14, 2003 to discuss eggplant pest management and breeding strategies with Dr. Rashid and coworkers.

S. M. Roguel and R. Z. Relado met with and discussed social impact components of the IPM-CRSP project with two IPM CRSP Bangladeshi scientists training in the Philippines on July 2, 2003.

Presentations at Local and International Meetings

Regional networking was also accomplished by attendance and presentation of papers by IPM CRSP scientists at regional meetings in Asia. Participation during Year 10 includes:

Alberto, R.T. M.S.V. Duca, S.E. Santiago and S.A. Miller. 2003. First report of anthracnose of onion in the Philippines. Poster presented in the Poster-Discussion Session during the 8th International Congress of Plant Pathology in Christchurch, New Zealand. February 1-7, 2003.

Arida, G.S., B.S. Punzal, C.C. Ravina, Jr., V.P. Gapud, E.G. Rajotte, and N.S. Talekar. 2002. Sex pheromones in pest management: the case of cutworm *Spodoptera litura* (F.) and armyworm *S. exigua* (Hubner) in onion. Paper presented during the 17th Anniversary Seminar Series. Philippine Rice Research Institute, Science City of Munoz, Nueva Ecija. 14pp.

Caasi-Lit, M.T., M.A.A. Capricho, E.G.deLeus, J.P. Mantala and I.L. Latiza. 2003. *Spodoptera litura* (Fabricius) and *Helicoverpa armigera* (Hubner): New Pests of Eggplant. Poster presented during the Annual Scientific Meeting of the National Academy of Science and Technology. Manila Hotel, Manila, Philippines. 11-12 July 2003.

Caasi-Lit, M.T., I.L. Lit, Jr. , M.A.A. Capricho, C.C. Lit, L.A.Q. Sison and G.S. Esguerra..2003. Effect of Weeding Levels on the Incidence of *Amrasca biguttula* (Ishida) on Eggplant. Poster presented during the Annual Scientific Meeting of the National Academy of Science and Technology. Manila Hotel, Manila, Philippines. 11-12 July 2003.

Gergon, E. B., S. A. Miller, R. G. Davide, O. S. Opina, and S. R. Obien. Evaluation of cultural practices (surface burning, deep plowing, organic amendments) for management of rice root-knot nematode in rice-onion cropping system and their effect on onion (*Allium cepa* L.) yield. 14th National Research Symposium, November 28, 2002, Bureau of Soil and Water Management, Diliman, Quezon City.

Gergon, E. B, S. A. Miller, J. Halbrendt, and R. G. Davide. 2003. Management of root-knot disease of onion (*Allium cepa* L.) caused by *Meloidogyne graminicola*. Poster presented at the 4th National IPM Symposium, April 8-10, 2003, Indianapolis, IN, USA.

Gergon, E. B., J. Halbrendt, S. A. Miller, and R. G. Davide. 2003. Management of root-knot disease caused by *Meloidogyne graminicola*. Poster presented at the 34th Scientific Conference and Annual Scientific Meeting of the Pest management Council of the Philippines. May 6-9, 2003. Cebu Business Hotel, Cebu City.

Gergon, E. B., S. A. Miller, J. Halbrendt, and R. G. Davide. 2003. Management of root-knot disease of onion (*Allium cepa* L.) caused by *Meloidogyne graminicola*. Poster presented at the the 34th Scientific Conference and Annual Scientific Meeting of the Pest management Council of the Philippines. May 6-9, 2003. Cebu Business Hotel, Cebu City.

Malasa, R. B., R. Z. Relado, and S. M. Roguel. 2003. Social impact assessment of using sex pheromone as a monitoring tool for management of *Spodoptera* species in onions. Paper presented during the Annual Conference of the Crop Science Society of the Philippines held at Aklan State University, Banga, Aklan, April 21-25, 2003.

Martin, E.C., A.M. Baltazar, J. M. Ramos, S.K. De Datta, L.T. Kok and E. G. Rajotte. 2003. Efficacy of *Spoladea recurvalis* as biological control agent for *Trianthema portulacastrum* Linn. 34th Annual Conference of the Pest Management Council of the Philippines. Cebu Business Hotel, Cebu City. May 6-9, 2003.

Martin, E.C., A..M. Baltazar, J. M. Ramos, S.K. De Datta, L.T. Kok and E. G. Rajotte. 2003. Efficacy of *Spoladea recurvalis* as biological control agent for *Trianthema portulacastrum* Linn. 19th Asian Pacific Weed Science Society Conference. Westin Philippine Plaza Hotel, Manila. April 17-21, 2003.

Opina, N.L., R.T. Alberto, S.E. Santiago, and S. Miller. 2003. Influence of host resistance and grafting on the incidence of bacterial wilt of eggplant. Poster presented during the 34th PMCP Conference and Annual Meeting Held at Cebu Business Hotel, May 6-10, 2003.

Punzal, B. S., G.S. Arida, C.C. Ravina Jr., V.P. Gapud, E.G. Rajotte and N.S. Talekar. 2003. Population dynamics of the leafminer, *Liriomyza trifolii* (Burgess) (Diptera: Agromyzidae) in onion *Allium cepa* Linn. grown after rice. Poster presented during the National Rice R&D Meeting, PhilRice, 31 March, 03 April 2003; Pest Management Council of the Philippines Scientific Convention, May 6-9, Cebu City, Philippines; 4th National IPM Symposium, April 8-10, 2003. Indianapolis, USA.

Technology Transfer

Technology transfer activities for Year 10 were highlighted by the publication of a special issue of the PhilRice Newsletter (Vol. 16 No.1 – see Publications, below) featuring the activities and achievements of the IPM CRSP, particularly the Philippines site. Training materials like the "Integrated Pest Management in Rice-Vegetable

Cropping Systems" Training Manual, three field guides on insect pests and diseases and their management and two technology bulletins have been prepared for publication. Furthermore, farmer field schools (FFS), farmer and Local Government Unit (LGU) workshops and field days were conducted. Two FFS and two field days were conducted in two sites - San Jose and Bongabon. The village level integration project in onion production was conducted in collaboration with the rice-based farming systems of PhilRice at two sites involving 17 IPM and 15 non-IPM farmer cooperators in Nueva Ecija. One farmer participatory research activity on grafted eggplant to reduce bacterial wilt incidence was established in three farmers' fields in Pangasinan. Furthermore, IPM CRSP scientists were key resource persons for IPM in vegetables in several training courses, farmers and/or agricultural technicians' meetings, workshops and the like. Semi-technical and technical papers were published in local and international scientific journals as well. Papers/posters were also presented at national and international conferences and conventions. Collaboration with the private sector, like NOGROCOMA, is still on-going. Initial discussions were also conducted between CropLife Philippines and IPM CRSP Philippines for possible collaboration.

Participatory on-farm trials were conducted for the third year in two villages in Nueva Ecija Province, Philippines to integrate the alternative IPM management strategies in onion. A modified farmer field school was conducted in which farmers met once a week for 10 weeks to learn and understand the alternative IPM strategies introduced. Results indicate that with the proper integration of sound pest management practices, farmers can generate higher yield and income compared to their conventional practices. In San Jose, IPM farmers increased onion yield by 6.62%. In Bongabon, yield obtained by the IPM farmers was higher by 29.78% compared to the non-IPM farmers. The IPM interventions reduced the production cost per hectare giving the farmers an income advantage of 31.32% (San Jose) and 49.44% (Bongabon). Moreover, the pest management cost in IPM fields incurred 55.80% and 27.11% savings over that of the non-IPM fields. These results are consistent with the results of the previous activities on village level integration activity. These encouraging results may pave the way for a faster dissemination of integrated pest management technologies to other areas in the country where onion is widely grown.

G. Arida and R. T. Alberto participated as resource persons during the meeting on Onion IPM in Palestina, San Jose City, February 28, 2003. This meeting was attended by Local Government Units, Agricultural Technicians and onion farmers from San Jose and Bongabon, Nueva Ecija.

G. Arida participated as a resource person during the Onion IPM meeting in Bongabon, Nueva Ecija, March 2003.

G. Arida and R.T. Alberto were resource speakers on Vegetable IPM in a Specialized Training Course on Rice-Based Farming System for Agricultural Technicians of Autonomous Region of Muslim Mindanao (ARRM), 12 February 2003.

G. Arida presented a lecture on Management of Insect Pests of Onion and Eggplant for IPM trainees from the International Rice Research Institute (IRRI), 04 April 2003.

R.T. Alberto was a Resource Person in the Village Level Integration of IPM Technologies in Bongabon, Nueva Ecija, 2003.

Publications

Baltazar, A. M. and Yu, A.-M. T. 2003. Integrating rice-vegetable pest management. PhilRice Newsletter 16(1):3.

Yu, A.-M. T. 2003. Integrated efforts for multiple pests. PhilRice Newsletter 16(1):4-5.

Yu, A.-M. T. 2003. Fitting the pieces of the IPM puzzle through IPM-CRSP. PhilRice Newsletter 16(1):6.

Roguel. S. M. and J. Laguna. 2003. What works, counts. PhilRice Newsletter, Vol. 16(1):7.

Casimero, M.C. and Pablico, S.M. 2003. Using alternative IPM strategies: Onion farmers reduce

costs, increase income. PhilRice Newsletter 16(1):10-11.

Barroga, R. F. 2003. PhilRice-U.S. scientists meet via videoconference. PhilRice Newsletter 16(1):11.

Baltazar, A.M. and Pablico, S.M. 2003. Cheaper, easier ways to control *mutha*. PhilRice Newsletter 16(1):12-13.

Yu, A.-M. 2003. Less insecticide use in Central Luzon. PhilRice Newsletter 16(1):13.

Arida, G.S. and Pablico, S.M. 2003. To spray or not to spray: sex pheromone traps tell when to spray for cutworm control. PhilRice Newsletter 16(1):14.

Gergon, E.B. and Pablico, S.M. 2003. Why farmers burn rice hull in fields. PhilRice Newsletter 16(1):15.

Pablico, S.M. 2003. Nuclear polyhedrosis virus beats cutworm. PhilRice Newsletter 16(1):16.

Baltazar, A.M. and Salac, R.L.S. 2003. IPM CRSP technologies in the pipeline. PhilRice Newsletter 16(1):17.

Roguel. S.M. 2003. Curiosity Pays Dividends: A Story of an IPM Convert. PhilRice Newsletter, Vol.16(1):18.

Arida, G.S,. B.S. Punzal, C.C. Ravina, Jr., V.P. Gapud, E.G. Rajotte, and N.S. Talekar. Monitoring adult populations with sex pheromone traps for effective timing of interventions against defoliators of onion (*Allium cepa* Linn.) grown after rice (*Oryza sativa* Linn.). Submitted for publication to the Philippine Entomologist Journal.

Arida, G.S., C.C. Ravina, Jr., B.S. Punzal, and E.G. Rajotte. 2003. Response of the onion plant *Allium cepa* L. to simulated pest damage. Paper submitted for the 15th National Research Symposium to be held on 8-9 October, 2003, Bureau of Agricultural Research, Department of Agriculture, Diliman, Quezon City. Also submitted for publication in the Philippine Entomologist.

Baltazar, A.M**.,** J.M. Ramos, E.C. Martin, M.C. Casimero, A.M. Mortimer, and S.K. De Datta. 2003. Managing purple nutsedge populations in rice-onion cropping systems through tillage. Proceedings 19th APWSS conference. March 17-21, 2003. Manila, Philippines. pages 129-136. (Finalist, Best Paper Competition, 19th APWSS conference,Manila, Philippines).

Casimero, M.C., A.O.V. Capistrano, S. Canete, N. Dasalla, R.G. Corales, L.M. Juliano, and A.M. Baltazar. 2003. Village level integration of integrated weed management strategies in rice-onion systems. Proceedings 19th Asian-Pacific Weed Science Society Conference. March 17-21, 2003. Manila, Philippines. pages 867-874.

De Datta, S.K. 2003. Globalizing weed science and IPM research, education and technology transfer. Proceedings 19th APWSS conference. March 17-21, 2003. Manila, Philippines. pages 1-15.

Gergon, E. B., S. A. Miller, J. M. Halbrendt, and R. G. Davide. 2002. Effect of rice root-knot nematode on growth and yield of Yellow Granex onion. Plant Disease 86:1339-1344.

Gergon, E. B., S. A. Miller, and Romulo G. Davide. 2002. Effect of rice root-knot nematode on growth and yield of onion. Transactions of the National Academy of Science and Technology Philippines 24 (1): 49-50.

Martin, E.C., A.M. Baltazar, R.P. Robles, J.M. Ramos, and S.K. De Datta. 2003. Efficacy of *Spoladea recurvalis* as biological control agent against *Trianthema portulacastrum*. Proceedings 19th APWSS conference. March 17-21, 2003. Manila, Philippines. pages 438-443.

Ramos, J.M., A.M. Baltazar, E.C. Martin, M.C. Casimero, A.M. Mortimer, and S.K. De Datta. 2003. Efficacy of selective postplant application methods of glyphosate against weeds in onion. Proceedings 19th APWSS conference. March 17-21, 2003. Manila, Philippines. pages 709-714.

Roguel, S.M., R.B. Malasa, and I.R. Tanzo. 2003. Social impact assessment of weed management strategies in rice-onion systems. Proceedings 19th APWSS conference. March 17-21, 2003. Manila, Philippines. pages 883-890.

Roguel, S. M., R. B. Malasa, and I. R. Tanzo. 2003. Social impact assessment of weed management strategies in rice onion system. Paper presented during the 19th Asian-Pacific Weed Science Society Conference, Westin Plaza Hotel, Manila on March 17-21, 2003. The paper was published as part of the conference proceedings.

Awards

Gergon, E. B. Scholastic Achievement Award, November 07, 2002, PhilRice, Science City of Muñoz, Nueva Ecija.

Finalist, Best Paper Competition, 19th APWSS conference, March 17-21, 2003, Manila, Philippines: Baltazar, A.M., J.M. Ramos, E.C. Martin, M.C. Casimero, A.M. Mortimer, and S.K. De Datta. 2003. Managing purple nutsedge populations in rice-onion cropping systems through tillage.

CARIBBEAN REGION

Overview of the Caribbean Site in Jamaica

Sue Tolin, Site Chair (Virginia Tech); Dionne Clarke-Harris, Site Coordinator (CARDI)

The Collaborative Program

The workplan 2002-2003 (Year 10) continued the focus on consolidation of developmental work and wider dissemination of developed technologies.

The main collaborating Caribbean and US Institutions of the Caribbean site are Caribbean Agricultural Research and Development Institute (CARDI) - Facilitator, Ministries of Agriculture (St Kitts and Nevis, Trinidad and Tobago, Barbados and St Vincent), Rural Agricultural Development Authority (RADA) in Jamaica, University of the West Indies, Jamaica Exporters Association, The Food Storage and Prevention of Infestation Division (Ministry of Commerce Science and Technology-Jamaica) Pennsylvania State University (PSU), Virginia Tech (VT), Ohio State University (OSU) and United States Department of Agriculture Vegetable Laboratory (USDA-VL).

IPM CRSP has been a catalyst for a number of initiatives in IPM throughout the region and continues to disseminate information on its activities to other Caribbean researchers through the Caribbean Integrated Pest Management Network (CIPMNET). The work of the IPM CRSP has been presented in numerous regional forums pertaining to IPM, in particular, and sustainable agriculture, in general. Some of the initiatives of the IPM CRSP have stimulated increased interest in the field of IPM resulting in a number of follow-up project proposals and projects especially with regard to hot pepper. In the other commodity groups viz. root crops and vegetables collaborative activities have been ongoing in territories outside of the host country.

IPM Constraints Addressed

Heavy reliance on pesticides in leafy vegetable production is of global concern. Caribbean site activities have focused on drastically reducing pesticide input through rational pesticide use. Achieving this objective would impact consumer safety and reduce environmental and user hazards. Methods to utilize threshold-based spray application decisions and the use of safer, less persistent, more selective pesticides are being developed.

The effective use of non-chemical methods is also being explored. Exclusion as a management option is being evaluated.

Sweetpotato weevils, sweetpotato leaf beetles, and the WDS (Wireworm-*Diabrotica*-*Systena*) soil insect complex significantly reduce sweetpotato production in Jamaica and the rest of the Caribbean. The incorporation of pest management tactics, such as resistant breeding lines and the use of biorational insecticides, into the present IPM technology will greatly assist IPM procedures for sweetpotato farmers in the Caribbean to produce high quality products which are competitive in international markets. Dissemination of IPM technology to farmers in major sweetpotato growing areas in the Caribbean is on-going to facilitate the goal of reducing pest damage and improving sweetpotato production such that it is competitive in the global market. Work was initiated to improve competitiveness of sweetpotato through eliminating viruses.

In hot pepper, the validation of integrated tactics identified to manage the virus complex as well as the broad mite and gall midge complex was initiated. This activity is geared towards

establishing an IPM model which addresses multiple pest constraints.
Currently, a complex of at least two species of gall midges is causing the export quarantine. We are now realizing that the biology and ecology of these species differ: We believe, for example, that one species primarily inhabits bud tissue, and one inhabits fruit pedicel tissue. Cultural control efforts include fruit stripping; this, plus the harvesting process itself, could result in differential effectiveness of management if one type of plant tissue is segregated. Molecular probes would enable IPM studies to occur at a species specific level.

Monitoring and surveillance of the gall midge, which is viewed as the critical component to addressing the USA's quarantine issues with this hot pepper pest, continues to be a major emphasis. At the field level, pepper plots across the island were sampled to identify pest-free areas or periods. Data collected suggest the possibility of economically-significant pest-free periods in four growing areas. This suggests more detailed investigations should be focused in these areas. Pest infestation data was posted on the PestWatch GIS Website, towards integration of World-wide Web and GIS for real-time monitoring, communication and dissemination of pest management information. Field extension workers' surveillance capability has been enhanced through their participation in the project. This will strengthen Jamaica's capacity to meet Global Sanitary and Phytosanitary Systems trading requirements.

As a follow-up to the activities geared towards web-based information on interceptions at the port and trace-back, a proposal was prepared and submitted to COLEACP. This has since been approved. The software program developed in Year 9 is being populated with the farmer register (listing of Farmers) compiled since Year 7. Later a register of middle suppliers of fresh produce will be added.

Selected Research Accomplishments

Vegetable IPM

- Exclusion and biorationals using a threshold-based spray application guide, the use of which gave significantly improved protection of the crop from insect damage when compared to farmer practice with much reduced pesticide input of 100% and 46%-92%, respectively.
- Parallel experimental research activities were initiated in Jamaica and Trinidad to test rational pesticide use strategies against lepidopteran pests of cabbage. Biorational pesticides spinosyn and lufenuron are being tested by varying the frequency of applications based on established thresholds compared to weekly applications.

Sweetpotato IPM

- Fifty-nine sweetpotato entries were evaluated for resistance to soil insect pests in South Carolina. Of these, 19 had significantly higher percentage clean roots than the susceptible check cultivar 'Beauregard' and 22 of 23 entries had WDS ratings significantly lower than the susceptible check cultivar 'Beauregard'. Significant resistance to white grubs, flea beetles, and sweetpotato weevils was also observed. This indicated high levels of insect resistance throughout this germplasm base.
- In the management of the sweetpotato leaf beetle, preliminary results indicated that imidacloprid was most effective against adult beetles, followed by neem formulation.
- Floral-lure baited traps were very efficient for monitoring the spotted cucumber beetle, *Diabrotica undecimpunctata*, which is part of the WDS pest complex.
- Overall, less insect damage was observed on sweetpotatoes grown in a killed cover crop (crimson clover), minimum tillage system than in conventionally tilled plots. Additionally, weeds had a significantly greater detrimental effect on yields in the conventionally tilled plots than in the killed cover crop plots.
- Four Jamaican cultivars, Quarter Million, Six Weeks, Sedges, and Fire-on-Land, were established at the USDA Plant Germplasm Quarantine Laboratory, and have tested positive

for feathery mottle virus, a geminivirus, sweetpotato vein mosaic, and sweetpotato virus G, but were not infected with four other viruses. Virus elimination is in progress.

IPM for Broad Mite on Hot Pepper

- Larger populations of broad mites (mean of 18.7 mites per leaf) were recovered in samples taken from six fields with high pesticide use, compared with those from six fields with no pesticide usage (8.4 mites per leaf). Conversely, populations of predators were higher in fields with no pesticide usage (10.3 mites per leaf) than in fields with high pesticide usage (4.3 mites per leaf).
- Broad mites were confined mainly to the lower leaves of the plants whereas predators were distributed more evenly over the plant, but the largest proportion (68%) was on the upper leaves in the unsprayed fields and a similar ratio (69%) on the upper leaves of the sprayed plants.
- Broad mites usually infest the upper parts of pepper plants and gradually move down the plants with time. These distributions on pepper plants suggest that it is predation at the early stages of infestation that is most important.
- Abamectin, diafenthurion and hexathiazox have provided the best combination of having maximum suppressive effects on broad mite populations and least on its predators, which makes them very suitable to be used in integrated pest management programs for broad mite on hot peppers.

IPM for Gall Midge of Hot Pepper

- Possible pest-free periods of economically significant duration have been identified in four growing areas.
- Institutional capability of RADA, Jamaica's major agricultural extension agency, has been strengthened in the areas of Extension officer mapping skills and approach to field surveillance. This should impact positively on crucial plant health programmes now being implemented towards enhancing agricultural trade potential and protecting local agriculture, human health and environmental well-being.
- The Web GIS program, PestWatch, has been launched on the RADA website and over two hundred entries posted. Efforts continue to overcome problems with data display.
- Two Caribbean scientists benefited from short-term training opportunities in the US to develop their knowledge base in the field of biotechnology - one of the emphases of IPM CRSP for Year 10.
- Work has begun in the development of molecular probes for gall midges on Jamaican hot peppers. This pioneer effort, if successful, will have a major impact on Jamaican agriculture as well as applicability to similar pest problems where rapid pest diagnosis is needed.

Technology Transfer

- The dissemination of information on management of pests of vegetable amaranth, using the two systems described above, is now being carried out on a wider scale as the national extension service, RADA, has been convinced of the value of the approaches for callaloo farmers. The Jamaica Organic Agriculture Movement JOAM has also adopted the exclusion method as an option for organic growers and has been given technical assistance towards the establishment of a demonstration plot on the grounds of Kings House (Residence of the Governor General of Jamaica). The Governor General of Jamaica has an avid interest in organic farming and has endorsed the promotion of alternative technologies.
- On August 1-3, 2003, all technologies and activities conducted by CARDI/IPMCRSP were displayed to over 40,000 patrons at the Annual Denbigh Agricultural Show. The display included posters and demonstrations.
- A sweetpotato IPM workshop was held in May, 2003 during which thirteen RADA officers from the parishes of Trelawny and Westmoreland were trained in identification of major pests of sweetpotato, IPM principles and

strategies used in the management of the sweetpotato weevil, the proper use of the sweetpotato weevil pheromone trap and the complementary practices that should be carried out to ensure its effectiveness.

- CARDI St. Kitts/Nevis hosted a two-day Sweetpotato Symposium in November,2003 during which presentations were made on aspects of sweetpotato production and marketing, a taste test of different lines conducted and a meeting of regional and local scientists held to develop proposals for projects and activities to advance the regional sweetpotato industry. Participants included Scientists from CARDI and UWI, farmers, bakers, marketers, processors, nutritionists and agri business entrepreneurs.
- July 2-5, 2003, a poster exhibition was mounted during a CARICOM conference at the Prime Minister's Office, Kingston, Jamaica
- September 23, 2003, IPM CRSP's collaboration and support was given special mention in a media interview by the government's Jamaica Information Service. Excerpts of this interview have been aired on several national radio and television stations.
- October 6-10, 2003, posters were mounted during the Caribbean Week of Agriculture at the Agricultural and Industrial Trade Show held in Georgetown, Guyana.
- October 16, 2003, posters, brochures fact sheets and annual reports were displayed and distributed during the National Exhibition for World Food Day, Kingston Jamaica.

Networking Activities

- December 9-14, 2002. D. Clarke-Harris attended CTA/CARDI/IICA Workshop on Strengthening Resource Mobilization and Project Development Capacity of Regional Networks, Trinidad and Tobago.
- February 1-2, 2003, Dr. Jackson attended the National Sweetpotato Collaborators Meeting, Mobile, Alabama.
- February 3-7, 2003, S. Tolin attended the International Congress of Plant Pathology and an International Workshop on Plant Virus Epidemiology, networking with several IPM CRSP scientists and researchers, in Christ Church, New Zealand.
- February 17, 2003. D. Clarke-Harris attended a meeting of the Hot Pepper Task Force to update collaborators on the upcoming project review
- February 23–28, 2003. Drs. Shelby Fleischer (PSU), Sue Tolin, IPM CRSP Site Chair, (VT), Janet Momsen, (University of California-Davis), Clive A Edwards, (OSU), and D. Michael Jackson (USDA Vegetable Laboratory, Charleston South Carolina), E. A. "Short" Heinrichs Interim Program Director IPM CRSP (VT) and Robert Hedlund, Cognizant Technical Officer, (United States Agency for International Development, Washington) visited the CARDI Jamaica unit. The purpose of the visit was to attend the annual review and planning meeting of the IPM CRSP (US and local collaborators) and develop the work plan for the next project year (Year 11). The meeting was held at the CARDI Jamaica, Kingston office. In addition, they visited several field sites where research is being conducted.
- March 11-12, 2003. D. Clarke-Harris met with IPM CRSP collaborators in Trinidad to work out details of the implementation of the two activities planned in the regionalization of vegetable IPM under IPM CRSP
- April 8-9, 2003. D. Clarke-Harris, K. M. Dalip, Sue Tolin, S. Fleischer, D. M. Jackson and Phillip Chung (Regional Coordinator PROCICARIBE CIPMNET attended the IPM National Symposium at the Westin Indianapolis Hotel, Indianapolis, Indiana.
- April 10-12, 2003. D. Clarke-Harris, K. M. Dalip, Sue Tolin, S. Fleischer, D. M. Jackson and Phillip Chung participated in the Annual Planning Meeting of the IPM CRSP at the Westin Indianapolis Hotel, Indianapolis, Indiana.
- July 13-19, 2003. D. Clarke-Harris participated in the 39th Annual Meeting of the Caribbean Food Crops Society, Grand Grenada Beach Resort, Grand Anse, Grenada and presented a paper, *Rational Pesticide Use in IPM of Pesticide-reliant Vegetable Crops in the*

Caribbean. This paper gave an overview of the relevance of work done on vegetables under IPM CRSP since 1994.

- August 9-13, 2003. S. Tolin participated in the American Phytopathological Society, and interacted with S. McDonald (MINAG), Maria Roye (UWI – Biotechnology), and M. R. de Doyle (Zamorano, Honduras), and sweetpotato virologists.
- October 20, 2003. S. Tolin met with S. Hurtt, USDA Plant Germplasm Quarantine Laboratory, Beltsville, MD, to view and discuss testing for and eliminating viruses in sweetpotato germplasm from Jamaica
- Drs. Jackson and Bohac served as members of the Sweetpotato Crop Germplasm Committee.
- Dr. Jackson shipped proprietary (Trécé) lures and traps to co-operators in Jamaica.

Regionalization of IPM Technology

Vegetable IPM

- March 11, 2003. D. Clarke-Harris and Lilory McComie visited a crucifer production area in Aranguez North, Trinidad to observe field trials by Tracmac Engineering, an agrichemical distributor in Trinidad conducting efficacy trials on Spinoace 120 SC (spinosyns), the biorational selected from studies conducted in Jamaica as very effective against Lepidoptera.
- Following a regionalization workshop, *Development of IPM in Leafy Vegetables that Currently Experience High-pesticide Input*, held in Trinidad 12-13 June 2002, parallel experimental research activities were initiated in Jamaica and Trinidad to test rational pesticide use strategies against diamond-back moth in cabbage.
- In July 2003, data collection for Participatory Rural Appraisals was carried out in Barbados and Trinidad.

Sweetpotato IPM

- Varietal trials continued in St. Kitts. White grub damage was higher than in previous years. Several lines continued to give good yields and showed tolerance to sweetpotato weevils.
- In St. Vincent, a baseline survey of sweetpotato farmers revealed that the sweetpotato weevil appeared to still not be present on the island. Some farmer practices, however, did seem to facilitate attack by the West Indian sweetpotato weevil.

Impacts

Leafy Vegetables

Addressing the problem of over-reliance on pesticides in leafy vegetables will have far reaching effects on consumers, users of pesticides and the environment. Rational pesticide use alone has demonstrated the potential to reduce pesticide inputs by more than 50% and, coupled with the use of less persistent pesticides, would create a significant impact. Tackling the cosmopolitan problem of heavy pesticide use against the diamond back moth is strategic, as this will have widespread applicability throughout the Caribbean.

Through the processes of dissemination, namely training, regional conferences, exhibitions and CIPMNET, other IPM initiatives throughout the region will benefit from these results and experiences.

Sweetpotato

Although sweetpotato is an important traditional crop for many countries in the Caribbean, both as an export product and as a staple in the local diet, several similarities and differences exist among the islands of the region. However, the availability of suitable land is a constraint and new alternative tillage systems are needed in the Caribbean to combat soil erosion and weed problems. The killed-cover crop system demonstrated had the added advantage of reducing damage from soil insect pests of sweetpotato.

The development and eventual incorporation of new monitoring and management techniques for the major sweetpotato pests, along with the identification of several sweetpotato varieties that

show tolerance to the major pests, the elimination of viruses, and the potential inclusion of botanical insecticides, biorationals, and pheromones, will contribute to the effectiveness and success of an IPM program for sweetpotato.

Hot Pepper

With the USDA revision of the mandatory fumigation requirement for hot peppers exported to the USA from Jamaica, the Jamaican farmer exporter has the opportunity to maintain a competitive presence in the US marketplace. The traceability system, as well as the Web-GIS field monitoring database established, will play a significant role in effective monitoring and surveillance.

The data collected during field surveys will not immediately impact on gall midge management. The exercise so far has, however, enhanced the technical skills and approach of extension officers involved in field surveillance. Exposure to sampling, mapping and GPS technology are notable. This has strengthened the institutional capability of RADA to better implement plant health field surveillance programs, now of growing importance to Jamaican agriculture and international trade in fresh produce.

At least two additional years of detailed work on hot pepper gall midge distribution and incidence will identify whether areas or periods of gall midge-free infestation exist. Where they do, this will provide a basis for minimizing fumigation requirements for Jamaican hot pepper exports to the United States, thereby enhancing the sustainability of Jamaica's share of the lucrative US fresh hot pepper market. Associated benefits will accrue to growers, exporters, distributors and the rural economy.

Molecular probes will enable IPM studies to occur at a species specific level. Molecular-based data are also becoming increasingly important for defining the taxonomy, systematics, and host-plant relationships of gall midges; therefore, this knowledge will improve taxonomic placement.

Overview of the Eastern European Site in Albania

Doug Pfeiffer, Site Chair (Virginia Tech); Charlie Pitts, Alternate Site Chair (Pennsylvania State University); Josef Tedeschini, Site Coordinator (Plant Protection Institute)

The Collaborative Program

The olive IPM research program in Albania has continued during 2002-2003 and was concentrated in two major activities:

1. Educational/planning activities and crop/pest monitoring, and
2. Multidisciplinary pest management experiments.

The work during Year 10 was conducted based on close cooperation between scientists of the Albanian agricultural research institutes and different US universities.

The major Albanian institutions involved are the Plant Protection Institute (PPI), Durres, Fruit Tree Research Institute (FRTI), Vlora and Agricultural University of Tirana (AUT). Partner US institutions are Virginia Tech, Penn State and University of California.

The Year 10 work plan was focused on olives and pest management problems and constraints identified in the Participatory Analysis. Planning and collaborative research took place through discussions among host country and US scientists at planning meetings in Albania. The research was based taking into consideration the developing results of last year.

Field research was conducted at the experimental station of FRTI and in two villages. The monitoring activities were done in several locations in the Vlora region.

Different laboratory analyses were conducted at FRTI, PPI and AUT. The Site Chair and Site Coordinator have maintained frequent communication and all co-PIs are encouraged to maintain communication with their respective collaborators on individual research activities.

The host country Site Coordinator frequently oversees the field research activities together with the other specialists involved in particular research topics.

IPM Constraints Addressed

The key constraint addressed in Albania in Year 10 was the need to improve the IPM solutions on specific pest problems in olive production. Specific major pests being addressed during this year in the IPM program were olive fruit fly *(B. oleae*), olive moth (*P. oleae*), black scale (*S. oleae*) leaf spot disease, olive knot, some minor pests and several weeds.

The main constraints to olive IPM addressed by this research have been:

- Lack of knowledge among olive growers on basic aspects of beneficial species biology;
- Gaps in knowledge in Albania on species composition of pests and the beneficial species complex;
- Lack of supplies for normal pest management programs.

Selected Research Accomplishments

Descriptions of research progress and results are provided in the individual activity reports. An overview of the key results obtained at the Albanian site is given as follows:

Monitoring of Crop Pests and Their Natural Enemies in Olive Production Systems

The main research IPM activities during 2002-2003 were done at the Experimental Station of FRTI

(Shamogjin) in the Vlora region. Field surveys were conducted for the incidence of pests, diseases and weeds in olive orchards. For the monitoring of key pests, different pheromones were tested. The development of new insect monitoring techniques for olive pests, such as olive fruit fly and olive moth, will serve to increase the variety of tactics that can be incorporated in an effective IPM program for olives. The status of a number of insect pests and disease species occurring in the olive crop has been identified, along with their potential to cause damage. The most important pests causing significant damage remain olive fruit fly and olive moth. The olive moth *P. oleae* continues to be one of the most serious pests on the early ripening variety (KMB).

The olive fruit fly adults are very active from September till October with the maximum of catches during the first week of October. Olive fruit fly infestations this year started at the beginning of September and didn't reach high levels until the second week of October.

The observations of the population dynamics of the black scale, *S. oleae* (year 2002) showed that it has one generation per year. The survey indicated that the black scale overwinters as first, second and third nymphs. The first and second stages were dominant. The eggs were laid during May with a peak population development the first week of June. High temperatures and low humidity caused heavy natural mortality of nymphs in the summer. During the Year 2003, observations demonstrated that the black scale overwinters as first and second instar nymphs (50%) and mature females (50%). The hatching females started appearing during the first day of May and during the entire season of olive cultivation, the mean number of scales/sample units remained very low.

The effectiveness of natural enemies of black scales was evaluated in field conditions. Parasitism rates of *Scutellista cyanea* (a black scale natural enemy) were very high at several places and the activity of the parasitoid *Metaphycus* sp. had a big impact in the mortality of olive black scales. In the black scale population (during the Year 2003) the parasitism from *Coccidiphaga scitula* Rambur was also high and the presence of entomopathogenic fungi was recorded.

Another scale species, *Aspidiotus nerii* (Bouche) was found in olive orchards during autumn and were common in the spring season infestations of *Euphyllura olivine* (Psyllidae) and *Palpita unionalis* Hb.

The mite infestation represents another pest that will be included in our efforts to develop IPM approaches. In Vlora region, *Aceria* was the most important species among the Eriophyid mites living on olive trees. *Ditrymachus athiasella* and *Tegolophus hasani* were present too. The most susceptible was cv Kalinjot with the highest infestation on leaves, flowers and fruits. The infestation level of the mites this year was 10% lower than the previous year.

Observations made on olive orchards revealed again the presence of leaf spot and olive knot as two important diseases of olive trees in Vlora district. The incidence of olive knot was 1.4 galls /1m^2 of canopy and field monitoring showed a high level of leaf spot disease during the entire season, associated with a maximum of abscission of leaves. Severe defoliation of olive trees due to the fungus *Mycocentrospora cladosporioides* Sacc, the casual agent of the cercosporiosis, was observed in the experimental field during April. The most susceptible variety was again cv Frantoi.

The weed inventory was conducted in Vlora region to develop an effective weed control strategy. The surveys were taken in January and June and, after data collection, 34 different botanical weed families were recorded. The dominant species among the shrubs were *Dittrichia viscose* (L) W. Greuter and *Rubus ulmifolius* Shott, among the grasses *Koeleria gracilis* (L) Pers , *Bromus tectorum* (L), *Poa annua* (L), *Bromus sterilis* (L), *Cynodon dactylon* (Pers), *Lolium sp*. (L), *Lagurus ovatus*(L), *Aspera spica-venti* (L), *Festuca* sp *(L)* and *Alopecurus* sp (L), and among broad leaves most widespread were *Trifolium resupinatum (L), Trifolium pratense (Scherb), Trifolium angustifolium (L), Logfia sp*. (Gass), *Linaria spuria* (L) *Mill*, and *Spergularia purpurea* (L) Pers.

In general, all the data collected from this year's activities will serve to develop models that can be used to forecast pest outbreaks and establish acceptable levels of chemical pesticide use. These

will be used as a basis for the development of an IPM system.

Effect of Harvest Timing on Olive Fly Infestation and Olive Oil Yields and Quality

For 2002, due to the high level of olive fruit fly infestation starting in September on cv Frantoi, and to escape from fruit fly infestation (especially on early ripening cultivars), the early harvest of olive was not recommended. For that reason, chemical treatments were recommended.

Regarding the Kalinjoti cultivar (late ripening cultivar), the combination of early harvest method (during the first week of November) and the application of Eco-traps could maintain the olive fruit fly infestation at acceptable levels. In this case, the additional chemical treatments were not necessary. The experiments for 2003 will continue until December.

Organic Methods of Vegetation Management and Olive Insect Control

The efficacy of several application methods against weed and olive pests was evaluated during 2003. The experiments demonstrated that the use of several environmentally sound management methods can be integrated into IPM programs for olive organic agriculture, thus reducing the pollution due to pesticides.

The use of locally available wheat straw as a mulch material in olive trees provides effective control to suppress weed competition and to conserve soil moisture for a long period of time. In the mulching treatment, the productivity of olive trees compared with other treatments was distinctly observed. Mulching treatment should replace, in the future, the use of herbicides (Diuron and Glyphosate) that have also shown good results in controlling weeds in conventional production systems. The other treatments (cover crop, plowing, grazing), although showing moderate effectiveness against weed control, compared to the synthetic herbicides, their low cost, and ecologically favorableness and local availability make them promising alternatives to the synthetics.

To control the key pests of olive crops, alternatives which will provide minor risk to the farmers and the environment are being developed. The efficacy of the microbial insecticide Bt applied with a conventional high- volume air blast sprayer to control olive moth *P. oleae* is being evaluated. The results obtained clearly demonstrate that Bt is a product with an acceptable efficacy to control olive moth under field conditions. The bio-pesticide can be considered useful for farmers in the control of one of key pests on olives.

In the organic production system where Bt was used, the number of natural enemies was higher compared with those in the conventional system where the broad-spectrum insecticide BI58 (Dimethoate) was applied. Chemical insecticides significantly affected population densities and activities of native natural enemies, leading to erosion of useful arthropod biodiversity.

Due to moderate levels of olive fruit fly infestations, the control of the pest with bait treatments (protein hydrolysate + natural pyrethrum in the organic production system and protein hydrolysate + BI 58 in the conventional system) have been able to maintain the olive fruit fly infestation below economic threshold levels. Curative treatments were not necessary in such situations.

New systems for weed management, the reduction of insect populations with pesticides allowed in organic agriculture, the development of new products, and organic olives and oil for the export market are the impacts foreseen in this research.

Effect of Pruning on Olive Production, Infestation by Black Scale and the Incidence of Olive Knot and Timing of Copper Sprays to Control Leaf Spot and Olive Knot

During 2003, three levels of pruning severity (non pruned, light pruning and heavy pruning) were tested. In the trials conducted, the olive trees with the heavily pruned treatment gave a good linear vegetative growth. The volume of canopy had a good shape and plenty of shoots compared with other treatments and non pruned trees. Also, the number of fruit produced was much higher compared with the non pruned and lightly pruned

treatments. In addition, it is interesting to note that water sensitive papers attached to branches have demonstrated that spray penetration is much greater in trees with more open canopies indicating that the quality of application of plant health products can be improved.

Another experiment was carried out applying treatments with copper fungicides every month (October-May) to determine the best moment of spraying to control leaf spot and olive knot. The results of this year showed that the treatments during spring (March, April) and autumn (October, November) are more protective and the leaf spot disease management was improved effectively.

In general, this project will allow greater implementation of a non-chemical tactic and organically-acceptable products into olive IPM.

Pheromone-Based IPM in Olive and Effects on Non-Target Species

The "Attract and Kill" method, an improved form of mass trapping, was evaluated during 2003 in several olive groves to control olive fruit fly *Bactrocera oleae* Gmel. Results until the end of October, indicated that on early ripening cultivars (cv Frantoi), especially during this year, when the olive fruit fly developed moderate population densities, one killing device per tree provided adequate protection and, for that reason, curative treatments with insecticide were not necessary to keep the fly population and the fruit infestation at low levels.

For the late ripening cultivars (cv Kalinjot), the experiment will continue until December.

Mutuality of Benefits of the Research

Fruit specialists in Albania received training in modern techniques of biological control, fruit production and the implementation of IPM in a free market context. IPM practices not disruptive to ecological systems or human welfare will be developed allowing Albanian olive products to be competitive in an international market. The pest problems assessed in our studies are common and widespread in Europe and in all the region of olive cultivation. IPM approaches to manage these problems have broad applicability especially in the neighboring countries. The benefits to the US relate to observation of the IPM system in perennial cropping systems under a regime of low pesticide availability. American commodities are facing the loss of key pesticide groups and specialists will benefit from working in the Albanian system, especially in light of the recent introduction of the olive fruit fly into the US.

Institution Building

Funds provided by the IPM CRSP Albania supported the research program of the three institutions by supporting technical staff, travel to research sites and provision of supplies and books for experimental purposes.

Scientist Travel

J. Tedeschini and R. Uka travelled to Indianapolis to participate in the IPM CRSP Technical Committee and Planning Meeting, April 8-10, 2003, and to present the IPM research results at the Fourth National IPM Symposium.

J. Tedeschini and R. Uka travelled to Italy to participate in the IOBC Meeting on Pheromones and Other Semiochemicals in Integrated Control held in Erice (Italy) and to discuss with the Site Chair, D. Pfeiffer, the planned proposal, manuscripts and publications.

Human Resource Development

Two IPM CRSP researchers are using the results of IPM research activities to complete their theses for the "Doctor of Science" degree at the Agricultural University of Tirana. (Mendim Bacaj and Bardhosh Ferraj, FTRI).

One IPM CRSP researcher (Bujar Huqi, PPI) has completed his study on olive weed control and has obtained his Doctor of Science at AUT.

Networking Activities

The IPM CRSP research results have been presented in several workshops organized in the main regions of olive growing area.

The results obtained under this project were presented at the regional Conference of Horticulture held on 13 Feb 2003 in Fier district (organized by Department of Agriculture, Fier and financed by SOROS), which was attended by 150 specialists, researchers, extension officers and farmers.

The IPM research results and impacts were shared with researchers and olive growers during the Agro Business Fair organized by KASH and ABMC on 7-12 June 2003. Additionally, about 500 leaflets were distributed.

In cooperation with MoAF (Directory of Science and Extension Service), four regional workshops were conducted on August 27, 29, Sept 9 and 18, 2003. Four presentations were prepared from our project and participants (inspectors, Albanian olive growers, farm-advisers) received materials and leaflets from our colleagues. About 80 participants from the main region of olive cultivation (Vlore, Gjirokaster, Elbasan and Shkoder) attended and the techniques of control of the main pests, diseases and weeds were presented. The development of pests and diseases during the growing season was shown.

The results of the experiments on nematode monitoring and natural enemies were published in "Pemtaria" a periodic of FTRI (two publications).

The monitoring of olive mites, the results of organic methods of vegetation management and the olive insect, "Attract and Kill" method and effect of harvest time were presented with four posters during the Fourth National IPM Symposium held in Indianapolis on 8-10 April 2003.

During June 2003, the results of weed control in olive were presented at the Agriculture University of Thessaloniki. Also in Sicily, Italy (October 2002) the experience of the "Attract and Kill" method was shared with other international specialists.

This past September, in cooperation with, and funded by FAO, we conducted two workshops/demonstrations and distributed 10000 Eco-traps, to facilitate the understanding of tactics and to improve the control of olive fruit fly in Novosela district. Extension agents and a group of farmers were trained in the application of the "Attract and Kill" method. About 3000 leaflets were prepared explaining the new techniques of olive fruit fly control.

During October, the farmers of Novosela gained additional knowledge about improved IPM technologies for olive pest control through their participation in the demonstration trials and during the treatments of 35000 olive trees against pests and diseases, as based on our research recommendations.

BOARD OF DIRECTORS

The annual IPM CRSP Board of Directors Meeting was held at Virginia Tech on 27-28 May 2003.

Appointed Members:
Bobby Moser, Chair; (Ohio State University), Clark Jones (Virginia Tech), David Sammons (Acting Chair for Day 2; Purdue University), Tom Lumpkin (AVRDC), Sharron Quisenberry (Montana State University), Deanna Behring (Pennsylvania State University), Richard Robbins (North Carolina A&T University), Ed Kanemasu (University of Georgia), Hiram Larew (USDA), Jim Hill (University of California)

Ex-Officio Members:
S.K. De Datta (Principal Investigator, IPM CRSP, Virginia Tech), E.A. Heinrichs (Interim Program Director, IPM CRSP, Virginia Tech), Greg Luther (Assistant Program Director, IPM CRSP, Virginia Tech), Robert Hedlund (CTO, IPM CRSP, USAID)

Technical Committee Representative:
George Norton (TC Chair, IPM CRSP, Virginia Tech)

S.K. De Datta gave the Welcome Address and Report to the Board, entitled, "Looking Ahead After 10 Years of IPM CRSP". He said this year's Board meetings would be primarily devoted to issues that confront us before we write the renewal proposal. De Datta said he no longer represents Virginia Tech (VT) on the Board; Dr. C. Clark Jones, Vice Provost for Outreach and International Affairs, is the member of the IPM CRSP Board representing VT. This separates the management functions and Board duties as recommended by the Administrative Management Review (AMR) Team. E.A. "Short" Heinrichs was recruited to serve as Interim Program Director. IPM CRSP now has an updated operational manual, which has resolved many issues the AMR was concerned about. With additional USAID funding, IPM CRSP initiated six activities in biotechnology. The Mali Mission has agreed to provide $128,000 to conduct research on leaf curl virus. USAID wants the IPM CRSP to seriously engage in Mission priorities.

Major decisions made by the Board, and other major events during the Meeting, included:

- The minutes of the Board Meeting of 3-4 April 2002 were approved as they stood.
- Heinrichs presented an overview of progress in IPM CRSP over the past year.
- De Datta presented an overview of IPM CRSP budget issues.
- George Norton reviewed and critiqued the USAID IPM Subsector Review Panel Report for the Board. There was relatively limited mention of IPM CRSP in their report.
- There was a consensus to compose a letter from the Board to SPARE, addressing SPARE's recommendations to BIFAD and other important issues.
- David Sammons reported on SPARE's perspective on the IPM Subsector Review, which included the history of the Review process.
- Bob Hedlund provided USAID's perspective about the Subsector Reviews, IPM CRSP renewal, and other issues raised during the Board Meeting.
- The Board drafted an outline for the letter to SPARE and then discussed the details that should be in the letter (the letter was subsequently drafted and sent to SPARE within two weeks of the Board Meeting). It included: a) Description of Current Situation/Statement of Need; b) Future Trends/Initiative Areas for Economic Development and Poverty Alleviation; c) Why IPM CRSP is Well Positioned to Meet Future Needs.
- De Datta gave an overview of the history and future plans for the transgenic Bt eggplant project for Asia.
- Tom Lumpkin presented AVRDC's perspective on the transgenic eggplant project and related issues.
- Hedlund commented that two years ago USAID exerted pressure to implement biotech projects, and IPM CRSP was the most responsive of all the CRSPs in identifying and implementing biotech activities.
- Norton led a discussion on strategies for Phase III renewal of the IPM CRSP.

- Norton reported on the 2003 Technical Committee Meeting and Year 11 Planning Workshop to the Board. He distributed handouts showing the IPM CRSP sessions that Doug Pfeiffer organized for the Fourth National IPM Symposium in Indianapolis in April. About 16 posters from IPM CRSP were also presented at this Symposium.
- Greg Luther updated the Board on the publications, presentations and other products of the IPM CRSP. He also provided a summary of IPM CRSP degree, non-degree, and short-term student training.
- Sammons reviewed the two principal recommendations from the Board: (1) A letter be sent to SPARE from the Board in response to the IPM Subsector Review; (2) Recommendations with regard to the renewal process: that the ME work out a process that will include pre-proposals being submitted first, and this would be announced concurrently with a schedule for development of full proposals; the entire process should fit a timeline that will produce a full renewal proposal for presentation to SPARE by February 2004.

- Minutes of the Board Meeting are available on request from the IPM CRSP ME.

TECHNICAL COMMITTEE

The IPM CRSP Technical Committee (TC) held its main annual meeting in Indianapolis, Indiana on 11-12 April 2003. The Executive Committee (EC), which is a subcommittee of the TC, also met on 11 April 2003.

TC members for Year 10 of the IPM CRSP were:
George Norton, TC Chair;
Sally Miller, Site Chair, SE Asian Site in the Philippines;
Doug Pfeiffer, Site Chair, Eastern European Site in Albania;
Sue Tolin, Site Chair, Caribbean Site in Jamaica;
Keith Moore, Site Chair, West African Site in Mali;
Steve Weller, Site Chair, Central American Site in Guatemala/Honduras;
Mark Erbaugh, Site Chair, East African Site in Uganda;
Ed Rajotte, Site Chair, South Asian Site in Bangladesh;
Jeff Alwang, Site Chair, South American Site in Ecuador;
Rezaul Karim, Host Country Site Coordinator Representative;
Carolyn Sachs, Gender Specialist;
Michael Irwin, External TC Member;
S.K. De Datta, IPM CRSP Principal Investigator;
E.A. "Short" Heinrichs, IPM CRSP Interim Program Director;
Greg Luther, IPM CRSP Assistant Program Director;
Bob Hedlund, IPM CRSP CTO, USAID.

The Executive Committee met first to give the TC a starting point on the budget for Year 11. There was a consensus to allocate $50,000 to Albania to conduct a PA and then submit a proposal to the Mission based on it.

The Technical Committee then met. It was emphasized that IPM CRSP must demonstrate it is making every attempt to coordinate with the USAID Missions. George Norton asked all Site Chairs to identify activities for biotech, impact assessment, follow-up survey, technology transfer, and positioning for the next phase in terms of discussions with Missions.

Major decisions made by the TC, and other major events during the Meeting, included:

- Straightline the site budgets for Year 11, plus allocate $217,000 for biotech activities.
- Ed Rajotte was elected to the EC (Sue Tolin rotated off).
- George Norton was re-elected as TC Chair.
- Several issues regarding the IPM CRSP book were discussed, including potential publishers.
- Deadlines for Year 11 work plan development were set and other issues concerning the work plan were discussed.
- S.K. De Datta and Greg Luther reported that Eritrean scientists sent 10 proposals to utilize funds remaining from a grant to IPM CRSP from the USAID/Eritrea Mission. The total request is for about $42,000.
- Luther updated the TC on the publications, presentations and other products of the IPM CRSP.
- Ways to improve the IPM CRSP website were discussed.
- Implications of the IPM Subsector Review in USAID and possible responses by the IPM CRSP were discussed.

Minutes of the EC and TC Meetings are available on request from the IPM CRSP ME.

TRIP REPORTS, YEAR 10

Trip reports from Year 10 of the IPM CRSP totaled as follows:

Bangladesh: 2; Ecuador: 3; Guatemala: 4; India: 2; Jamaica: 2; Mali: 5; Philippines: 1; Trinidad & Tobago: 1; Uganda: 1.

These reports are all posted on the IPM CRSP web site: http://www.ag.vt.edu/ipmcrsp/index.asp.

Publications, Presentations and Other Products of the IPM CRSP										
Cumulative Compilation through May 11, 2003										
Category	*General/ Other*	*Albania*	*Bangladesh*	*Ecuador*	*Guatemala*	*Jamaica*	*Mali*	*Philippines*	*Uganda*	*Total*
Papers Published in Refereed										
or Reviewed Publication	0	0	2	15	13	19	7	21	40	117
Books/Book Chapters	0	0	0	0	2	0	0	1	0	3
Theses and Dissertations	0	0	3	11	8	4	3	5	13	47
IPM CRSP Annual Reports										
and Highlights	14	0	0	0	0	0	0	0	0	14
Extension Publications (large)	0	0	2	2	4	11	3	4	3	29
Proceedings										
(not refereed or reviewed)	14	0	0	4	67	16	10	42	11	164
IPM CRSP Working Papers	2	2	2	1	6	0	3	7	3	26
World Wide Web Sites										
and Documents	2	1	0	0	0	3	0	0	0	6
Germplasm Releases	0	0	0	0	0	7	0	0	0	7
Workshops, Courses, Field										
Schools and Field Days	0	3	2	31	28	21	10	10	23	128
Papers/Seminars Presented	0	6	0	38	101	73	35	47	137	437
Electronic Presentations	0	0	0	0	0	4	0	0	3	7
Posters	1	0	1	0	6	30	5	45	16	104
Fact Sheets (small ext. pubs.)	0	1	0	1	0	4	2	20	7	35
Newsletters	23	0	0	0	0	2	1	2	4	32
Videotapes	0	0	0	1	0	1	7	1	0	10
Magazine and Newspaper										
Articles	0	0	0	2	1	1	1	2	4	11
Reports	44	27	74	87	195	208	139	171	142	1,087
Abstracts	0	0	0	0	2	14	3	2	8	29
Bibliographic Databases										
and Miscellaneous	0	0	0	0	0	0	1	6	0	7
TOTAL	**100**	**40**	**86**	**193**	**433**	**418**	**230**	**386**	**414**	**2,300**